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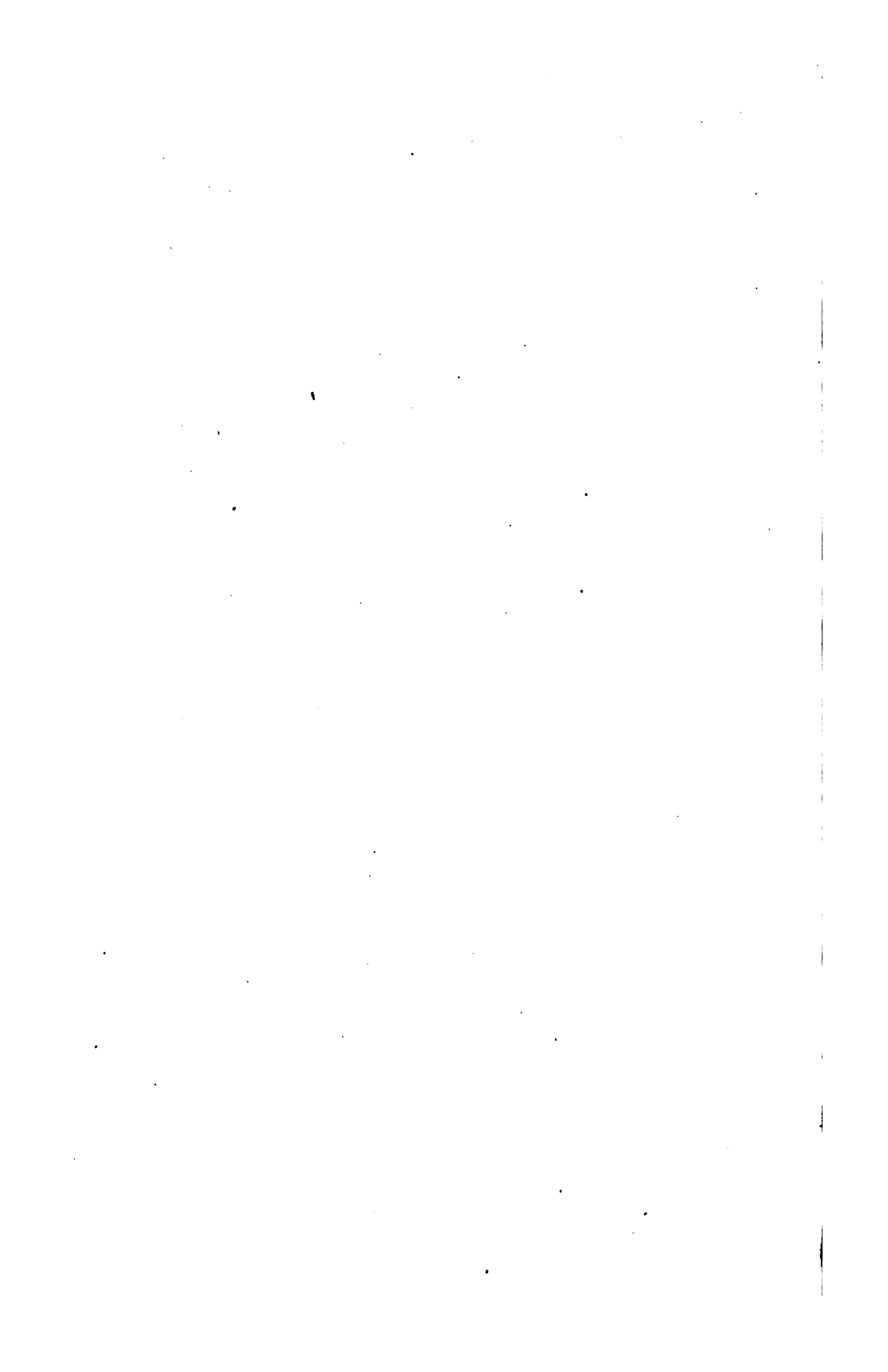
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BIOLOGICAL TEACHING

IN THE

COLLEGES OF THE UNITED STATES

BY

JOHN P. CAMPBELL, A. B., Ph. D. (*Johns Hopkins*)

PROFESSOR OF BIOLOGY IN THE UNIVERSITY OF GEORGIA

WASHINGTON
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CONTENTS.

	Page.
Letter of transmittal	5
CHAPTER I. Introduction	7
II. Detailed description of the biological courses offered by American colleges	12
III. The educational value of biological studies—School work	114
IV. College courses	123
V. University work in biology	140
VI. Laboratories and museums	156
VII. Marine laboratories	162
Table 1. Showing statistics bearing upon biological teaching in colleges	168
2. Showing the biological work of arts courses, together with the scientific subjects required for admission	172
3. Showing the biological work of scientific courses, together with the scientific subjects required for admission	176

DEPARTMENT OF THE INTERIOR,
BUREAU OF EDUCATION,
Washington, D. C., October 10, 1891.

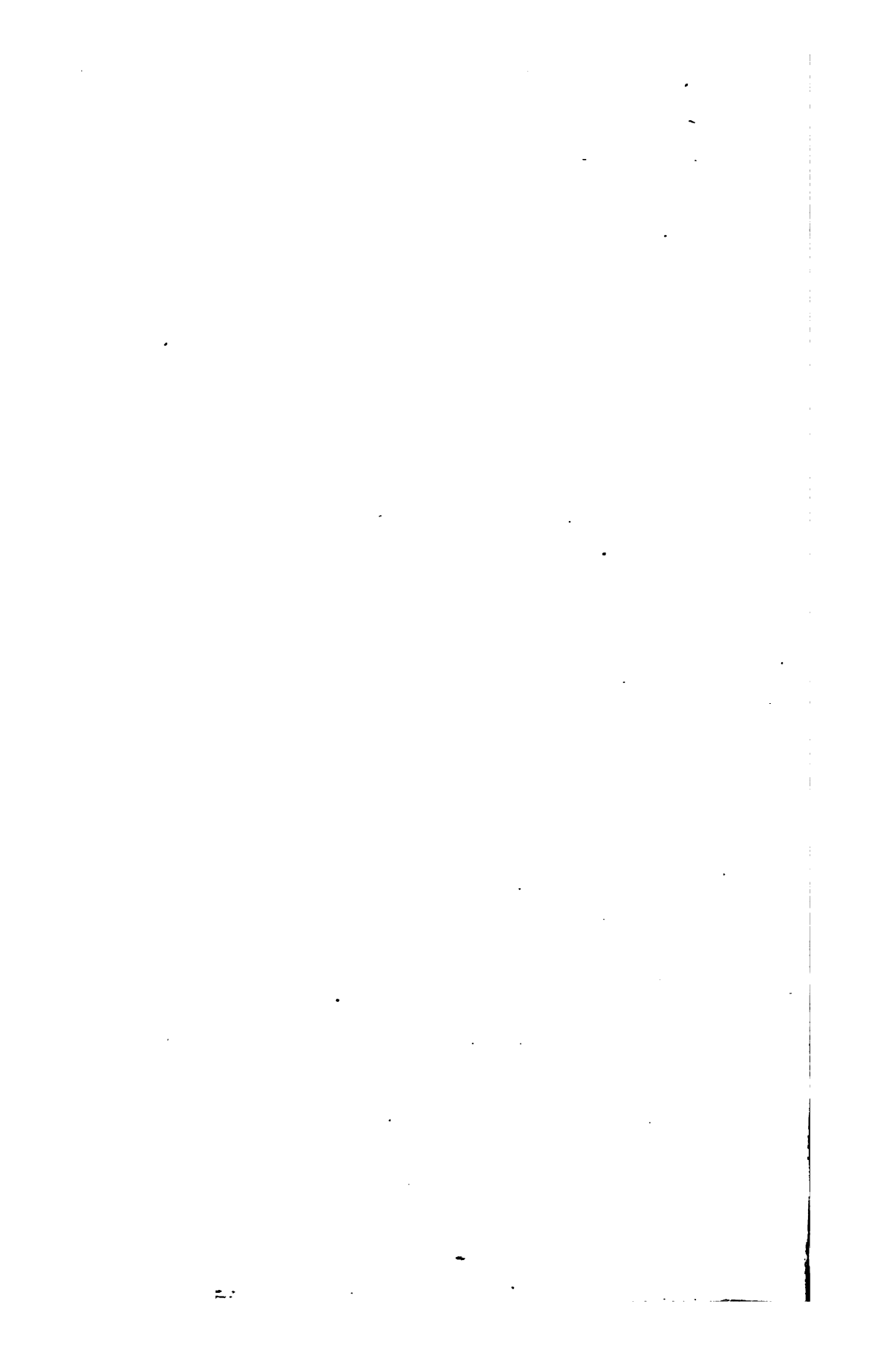
SIR: The most striking of the modifications in the college curriculum which have been made within the last half century is the enlargement of the sphere of instruction in the natural sciences. The older colleges built their course of study on mathematics, Latin, and Greek, but there has arisen in later times a tributary stream of human learning which includes three modern branches, natural science and the literature and history of modern nations. This is receiving more and more recognition in the course of study.

Appreciating the significance and importance of this newer line of study, I have gladly availed myself of the opportunity to institute an investigation of the methods pursued in one of its most important divisions, and accepted the offer of Prof. John P. Campbell, of the University of Georgia, to prepare a monograph on Biological Teaching in the United States. The results of his inquiries are here presented, in the belief that they will prove valuable to all teachers of science, whether in colleges or secondary schools.

I have the honor to be, sir, very respectfully,

W. T. HARRIS,
Commissioner.

Hon. JOHN W. NOBLE,
Secretary of the Interior.



BIOLOGICAL TEACHING

IN THE

COLLEGES OF THE UNITED STATES.

By JOHN P. CAMPBELL, A. B., Ph. D.

CHAPTER I.

INTRODUCTION.

Within the past 20 years or more there has been an unprecedented activity, especially in this country and England, in the development of methods for all branches of scientific teaching. The idea has been almost totally abandoned that a training, often more or less faulty, in languages, mathematics, and metaphysics constituted an education in any sense of the word; and it is now well-nigh universally recognized that scientific methods must be not only added but given a prominent place. Perhaps the most striking point by which the educational methods of the present are distinguished from those formerly in vogue is the great prominence which is given to inductive methods, and as a consequence, the little attention that is now paid to mere facts, as contrasted with the great stress laid on the processes by which those facts are acquired. It is now pretty well agreed that an ideal course of training should be broad, yet not too comprehensive; that it should be liberal, yet not technical; that it should develop rather than inform; and that it should exercise all the faculties rather than cultivate some at the expense of others.

Although the introduction of scientific methods into the teaching of languages, history, etc., has been followed by the most gratifying results, giving these studies a greater reality to the student, and in consequence a greater value than they ever before possessed, it still seems evident that something more is needed, and that a student only grasps these methods fully and acquires in the greatest degree that self-reliance, independence of thought, and accuracy of observation and reasoning which they are intended to impart, when he has, at least, his first exercise in practicing them upon something which he knows of his own knowledge, which is material and tangible, and which has therefore a real existence to him.

Many of the smaller institutions of the country, which have hitherto made liberal provisions for their literary studies and combined all of their scientific teaching into one or two chairs, have now seen the necessity for changing this order of things, and the "professor of natural science," upon whose shoulders rests the burden of instruction in physics, chemistry, zoölogy, and geology, with perhaps additional duties in other departments, is now almost extinct.

The absolute necessity for considerable science teaching in any liberal course of study is now generally admitted, and teachers seem almost unanimous in believing that the training in methods is the primary object of such work, and that the information involved, important though it is, must be given a subordinate place. It follows, therefore, that if the quality of teaching is what it should be, the methods of scientific inquiry, so far at least as they are common to all branches, may be learned by studies in one department of science quite as well as in any other. It follows, too, that in the arrangement of studies, in a college curriculum at least, all sciences must be given an approximately equal rank, equal so far as the general character of the logical methods is concerned, and varying principally in the extent to which they depend upon the two sources of information—observation and experiment.

It is as a means of training the observational powers that biology is chiefly valuable. In this respect it is surpassed by no one of the natural sciences, and indeed it possesses certain features which it shares with none of them. In spite of this the general improvement in the methods of teaching biology has come much later than in any of the sister sciences. In seeking for the cause of this it seems evident that the introduction of practical and rational methods into the teaching of chemistry and physics has been greatly facilitated by popular appreciation based upon the very erroneous but widespread idea that the final end and aim of chemistry is the ability to determine the composition of unknown substances, while physics finds a justification for its existence only in such occasional discoveries as the electric light and the phonograph. The educational value of practical work in chemistry and physics seems, therefore, to have been something of an afterthought, and to have been demonstrated only after such work had been performed for a considerable time with other objects in view.

The growth and development of methods for biological teaching have been marked by extreme suddenness, for which the reasons are manifold. There is a greater activity in the study of educational methods now than ever before, and the science of teaching certainly rests upon a far more rational basis than has ever been the case previously. The great development of technical and industrial education has also had the effect of making the courses in our liberal colleges more practical in character, and of bringing into deservedly greater prominence those branches into which training of the eyes and hands enters. The establishment of agricultural colleges by the General Government, and the

more recent establishment of agricultural experiment stations throughout the country, have greatly emphasized the necessity for instruction and research in certain branches of biology, and this has in turn had its effect upon the literary and scientific institutions with which many of these are in connection. In addition, the example of a few of the leading institutions of the country in greatly extending their biological courses, equipping new laboratories, and giving an altogether new character to the work, has greatly influenced the smaller colleges, and the authorities of most of those that have not done so seem now to recognize fully the fact that their greatest advances must be not along literary lines but in the direction of new and improved appliances for scientific teaching and research.

As regards the teaching of biology, the present period is one of exceeding interest. Considering chemistry and physics, we find that they have, to a great extent, passed through the experimental stage; and the methods of teaching, at least in the colleges, have come to be approximately the same everywhere. They are, of course, undergoing a certain amount of progressive improvement, but at present the methods employed in teaching biology show but little agreement, and the time is very remote, if, indeed, it ever comes, when any one method will be generally adopted, with all its details, as the best. The rapid advances of the past few years have in part been made possible by taking advantage of the experience of teachers in other fields of science, but, in large measure, they have depended upon conditions peculiar to biology itself.

The object of this work is to present the actual extent and scope of the biological courses offered by the colleges of the United States, together with the methods of teaching employed. It also aims at presenting as fully as possible an account of the equipment and facilities for teaching which the various colleges possess. The statements which follow are therefore based largely upon the printed accounts found in the college catalogues, supplemented in many cases by letters containing additional information. These have usually been rewritten, but where they are in suitable form they are quoted directly.

It should be borne in mind that many of the colleges announce more in their catalogues than they can possibly do thoroughly with the teaching force employed. This is often perfectly apparent, but in more than one letter received has the statement been made that certain courses have no existence save on paper. Even if this be so, the announcement may be taken as embodying the views of the professors in charge in regard to the nature and aims of such work, and representing the ideals toward which they are striving. Hence they have their value in such an inquiry as the present. Another difficulty which presents itself is that of forming an accurate idea of the material equipment of the various colleges from their catalogues. Those from the larger and better equipped colleges are usually silent on this subject, or at most give but

general descriptions of their laboratories and collections, while the smaller colleges are prone to give details to a much greater extent than their size seems to warrant. Fortunately, additional sources of information have been available in many cases, and it is hoped that no injustice has been done.

The relations existing between the schools and colleges then present themselves for consideration, and without going into the details of school methods further than seems necessary to show their bearing upon college work, the attempt is made to indicate the most recent developments in this line, and to show the attitude of leading teachers toward each grade of work. The educational value of biology, its relation to other sciences, and the best order and methods of teaching, are all questions which require consideration in this connection. On this subject the writer disclaims any intention of speaking with authority, and gives his own views and experiences only when they are supported by those of others.

The work of universities is then taken up and the attempt made to determine its true character and the extent of work now going on, after which the effort is made to show the facilities which the various institutions possess for laboratory work and investigation in the various branches of biology, under which head come the questions of laboratory construction and management, and the arrangement and equipment of museums.

The seaside study of marine animals has become sufficiently general and important to justify a special chapter being devoted to that subject.

Following this are tables condensing the most important points given in the detailed statement. Table 1 gives the names of the professors in charge of the biological work in the colleges from which reports have been received, while tables 2 and 3 show the relation of biological to other scientific work in a representative number of colleges.

The preparation of this work was first undertaken from a desire on the part of the compiler to know how his own facilities for work compared with those of other institutions of about the same size. He wished also to learn how his own standard of work compared with that elsewhere maintained, and whether certain difficulties with which he had to contend existed in other places, and, if so, how they were met.

It then seemed desirable to put on record certain points which were brought out, because of their possible value as bearing upon the evolution of permanent methods of teaching.

To obtain the information necessary, circulars were issued containing the following questions, with a request for any additional information likely to prove of interest:

- (1) At what stage is the college course in biology begun, and in what order are its various branches taken up?
- (2) How much time is given to class-room work; is this mainly by lectures, or is a text-book used?

(3) What facilities are provided for laboratory work; how much time is devoted to it; is attendance upon it required of all students in elementary courses?

(4) What facilities for research are afforded, and what is the general character of this research?

(5) How is your laboratory planned and constructed?

(6) Is any preparation in science required for entrance to your institution; and what high schools, academies, seminaries, etc., in your State provide an adequate preparatory course in science?

These were sent to the professors of biology in all the colleges of the country enumerated in the report of the Commissioner of Education for 1887-88, which had 50 students or more in the collegiate department, and to all the scientific schools. In spite of numerous failures to respond, a large number of letters, pamphlets, and catalogues were received, from which, in the main, the statements contained in the following pages are made.

CHAPTER II.

DETAILED DESCRIPTIONS OF THE BIOLOGICAL COURSES OFFERED BY AMERICAN COLLEGES.

ADELBERT COLLEGE.

CLEVELAND, OHIO.

A course in general biology is offered to students of the junior class. Such students have had in their sophomore year an elementary course in physics, of which laboratory work formed an important part. The biology course begins with the practical study of selected animal and vegetable types, and following this is a course in mammalian anatomy with which is connected elementary instruction in physiology and histology. To those students who have completed this work, there is offered a further course in the elements of zoölogy and botany. Courses will soon be provided in animal physiology, general zoölogy, osteology, and botany.

In all of these courses, practical work is greatly emphasized. Each student is required to spend 4 hours weekly in laboratory work, only 1 or 2 hours being devoted to lectures or text-book exercise.

The laboratory is well equipped for the work now offered. The department has been in existence but two years, and the laboratory was furnished with a view to providing for a general biology course first, leading up to more extensive work later as the opportunity presents itself. One large well-lighted room in the general college building is used as a laboratory, and connected with this is a preparation room used also as a dissecting laboratory. No provisions have yet been made for advanced research, and no original investigations have been undertaken.

Museum facilities are limited, consisting mainly of stuffed mammals and birds, and a small number of invertebrate specimens. The college possesses a herbarium containing a considerable collection of mosses and flowering plants.

No preparation in science is required of applicants for admission to Adelbert College, and there are but few schools in northern Ohio that attempt any kind of work in zoölogy. In the Cleveland high schools botany is an optional study in the third year. Chemistry and physics are also taught, but there is no instruction offered in zoölogy.

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS.

COLLEGE STATION, TEX.

Attention is paid to some branch of biology during almost the whole of the 4-year courses in agriculture, and during the first year of the mechanical course. For admission to these courses no entrance requirements are made further than the usual branches of an elementary English education.

During the first year of both courses, zoölogy is considered for 1 hour weekly, botany being also studied during the second and third terms. The course in zoölogy is of a general character, and the time devoted to botany is spent in acquiring the elements of the subject. Each student is required to prepare and mount 25 plants which he has himself determined.

During the sophomore year a general course in physiology is given, while two terms of the junior year are devoted to more advanced botany. Grasses and forage plants are considered in the first term, each student being required to identify and mount 25 species of grasses, while in the second, attention is given to economic and systematic botany. This course is rendered as practical as possible and is well illustrated by a museum containing numerous specimens of economic vegetable products from various parts of the world.

The subject of forestry is taken up in the first term of the senior year, after which attention is given to vegetable histology and cryptogamic botany, with especial reference to plant diseases, for the remainder of the year. This course is almost entirely practical, being planned to meet the special needs of the country in which the college is located.

Opportunities are given for special post-graduate work in botany and zoölogy, especially in their economic relations.

The zoölogical collection has been but recently begun, and contains but a few hundred specimens, mostly marine invertebrates and insects. The herbarium contains more than 1,000 species illustrating the flora of Texas, as well as numerous specimens from other parts of the United States. As further aids in the study of botany and horticulture the college possesses numerous orchards, gardens, greenhouses, etc., while the laboratory possesses appliances needed for the microscopic study of vegetable histology and plant diseases.

ALBION COLLEGE.

ALBION, MICH.

In the preparatory department a course is provided in systematic botany occupying 5 hours weekly through one term, this being followed by a course in physiology of the same length. Preceding these is a course in physics occupying $3\frac{1}{2}$ hours per week for two terms.

In the college course all students in the freshman class are required

to attend to zoölogy for one term, giving 4 hours weekly to a series of lectures and practical exercises with specimens. Sophomores in the scientific and English courses are further required to take a course in biology, to which 3 hours weekly are devoted during one term.

In the junior and senior classes the studies are almost entirely elective, a short course in chemistry being the only scientific work required. In these classes a course in microscopy is first offered as a preliminary to the more special work. In this course the student spends 6 hours weekly for one term in learning the technique of the microscope, and the methods of preparation and mounting of objects for microscopic study. A course in general biology is offered, consisting of 6 hours laboratory work each week for one term. In this course, low forms of life, both animal and vegetable, are dissected. Two courses follow this, one in animal biology, the other in vegetable. Both are laboratory courses, and the same time, 6 hours per week, is given to each. The work consists in the minute examination of a series of animal and vegetable forms. Students are required to collect their own material as far as possible, make their studies from the objects themselves, make abundant notes and drawings during the progress of their work, and when this work is completed they are required to submit written reports containing the results.

A "research class" is formed which meets once weekly for the discussion of current biological literature and the consideration of special topics. Attendance upon this course is limited to those who show special proficiency in biological work. Special laboratory work may also be planned for such students.

Special emphasis is laid upon the general biology course. In it the student is brought in contact with the objects themselves, beginning with simple forms and passing on to more complex. Brief directions for study are furnished, but the information sought must be gotten by the student himself from the objects.

The laboratory contains abundant tables for all students, and microscopes in sufficient number for each student to have one for his own use. There are, in addition, abundant appliances, and these are rapidly increasing.

Albion College admits students from many of the high schools of the State without examination. In these schools the scientific work done approximately equals that of the preparatory department of the college.

ALLEGHENY COLLEGE.

MEADVILLE, PA.

Three courses of study are provided, all of which lead to the degree of bachelor of arts. An elementary knowledge of physiology, physics, and botany is required of all candidates for admission to these courses.

The college work in biology begins in the freshman class, where the work for all courses consists of two terms in zoölogy and one term in

botany, 5 hours weekly being devoted to each. In the sophomore year biology is only required of students taking a scientific course. Such students spend the first term in more advanced work in botany, the second in the practical study of comparative anatomy, in general microscopic work, and histology.

No scientific courses precede biology, chemistry not being taken up until the sophomore year, while physics and geology come in the junior and senior, respectively.

Practical laboratory work is not made a required part of the course, but opportunities for such work are offered to students who care to avail themselves of them. Botany is taught by a class-room drill in which the drawing and analysis of wild flowers is required. Each student is also required to prepare a herbarium from the local flora.

A post-graduate course in natural history is offered, in which the second year is devoted to botany and the third to zoölogy. In this course opportunities are afforded for special study of the structure, physiology, and distribution of plants, and a similar study of special groups of animals.

The laboratory facilities are suited only for elementary work. One well-lighted room is fitted with tables, cases, etc., and the equipment consists of microscopes and accessories. No provisions are made for advanced research.

The museum consists of a collection of about 3,000 species of insects, 1,000 specimens of birds, reptiles, fish, and marine animals, and more than 6,000 specimens of shells, all arranged and classified.

Allegheny College has its own preparatory department, from which students are admitted to college on certificate. Most of the schools of the State furnish adequate preparation in science.

AMHERST COLLEGE.

AMHERST, MASS.

The work in biology is all elective. It begins with a course in phænogamic botany in the third term of the sophomore year. This occupies 4 hours weekly, and about one-third of the time is devoted to field and laboratory work. In the junior year two terms are devoted to invertebrate zoölogy and the third to cryptogamic botany. To each of these 4 hours weekly are devoted, and one-third to one-half of the time is given to laboratory work. The senior year is devoted to the comparative anatomy and systematic relations of the vertebrates, short courses being also given in embryology and histology.

Laboratory work is required of all students taking any of these courses. The laboratory is supplied with microscopes and all the appliances needed in undergraduate work, no provision being made for research. For aiding the work of instruction there is a natural history collection of considerable size. It contains representatives of all the great groups of

animals and plants, as well as numerous models and skeletons. The most striking feature is the collection of about 600 birds made by Audubon, many of which are the type specimens.

For admission to the freshman class no knowledge of any scientific subject is required.

AMITY COLLEGE.

COLLEGE SPRINGS, IOWA.

An elementary knowledge of physiology is required of all candidates for admission to the freshman class. This is provided for in the preparatory department as well as in the Amitonian Academy and other schools of the State.

The scientific work of the college begins with a course in geology in the third term of the sophomore year. In the junior class general biology is taught in the first term, followed by zoölogy in the second and botany in the third. During the junior year advanced physiology is also offered as an elective.

In connection with these courses is a considerable amount of practical work. During the entire junior year, 5 hours weekly are devoted to lectures or recitations and 6 hours to laboratory work.

The general biology course consists of the examination of a series of plants and animals, the student being required to observe for himself and make written reports on his observations. The work in zoölogy is so designed as to give the student an accurate knowledge of a few typical forms, their structure, development, and life history, and upon this basis is presented the classification of animals. By means of the practical work the student gains considerable technical knowledge, but, what is vastly more important, has his powers of observation, comparison, and generalization quickened. Botany is taught in the same general manner as zoölogy. Attention is mainly given to flowering plants, the student dividing his time between vegetable morphology and physiology. Each student is required to determine 20 species of flowering plants, after which a limited number of cryptogams are studied in the same way.

ARKANSAS INDUSTRIAL UNIVERSITY.

FAYETTEVILLE, ARK.

In the eight courses of study which this institution provides, biology does not occupy a very prominent place, being in most of them confined to the subfreshman class. In this class the requirements are nearly uniform in all courses, consisting of elementary zoölogy, to which is devoted 1 hour per week during one term, and elementary botany and physiology, to which 2 hours per week are devoted during the two remaining terms. No more than this is required except in the case of students taking agricultural and scientific courses. In the former, physiology, botany, and zoölogy are taken up in the freshman class in

the order indicated, 5 hours weekly during one term being devoted to each. In the sophomore year structural botany is studied for one term, followed by a course in entomology, each course occupying 2 hours per week. The requirements in the B. S. course are the same as in the agricultural with this addition, that a course in advanced biology occupying 4 hours weekly during two terms is offered as an elective to senior students.

The courses are largely conducted by means of text-books, and while some laboratory facilities are provided, attendance upon the laboratory is required only in the sophomore class. No special provisions are made for advanced work either in the arrangement of courses or in laboratory equipment.

The university possesses a herbarium containing more than 2,500 specimens of the plants of Arkansas; and other extensive collections are in progress. It possesses also about 500 zoölogical specimens.

AUGUSTANA COLLEGE.

ROCK ISLAND, ILL.

As a preliminary to the work of the college there are offered, in the last two years of the preparatory department, courses in human physiology, botany, and zoölogy. The botanical study is limited to the examination of flowering plants, a series of wild and greenhouse specimens being employed to illustrate the terms used in descriptive botany and to familiarize the student with the differences of structure in the larger divisions of flowering plants. During the spring term 4 hours weekly are devoted to the analysis of flowers, one lecture each week being given to the subjects of economic botany and distribution of plants. Each student is required to prepare a herbarium consisting of 75 specimens of wild plants.

In the scientific course attention is given to cryptogamic botany and vegetable histology. This is carried over into the freshman class of the college course, and consists of a thorough examination of a series of typical plants, one of each kind being dissected.

The preparatory course in zoölogy consists of a practical study of selected animal types, thus furnishing the basis for a more extended course in systematic zoölogy. The college work in zoölogy is limited to one term in the junior year, which is devoted to the study of conchology, 2 hours weekly being devoted to lectures and 3 to practical work, as in the botanical course. The laboratory has been recently fitted up. It is arranged with special reference to large classes of beginners, and is provided with twelve microscopes and accessories; also dissecting instruments in sufficient number. No provision is made for advanced research.

Augustana College possesses a good museum, well arranged and convenient for teaching. It is especially rich in shells.

The preparatory and collegiate departments are under the same management, and their courses are in harmony with one another. No previous training in any branch of science is necessary to enter the preparatory department. Most of the collegiate students receive their preliminary training here.

BELOIT COLLEGE.

BELOIT, WIS.

The biological work of this institution begins in the freshman year with a course in general biology, consisting of laboratory work occupying 8 hours weekly during two terms. The third term is devoted to botany, the work occupying 15 hours per week. This time is in part devoted to systematic botany, but vegetable physiology and cryptogamic botany also receive attention. The laboratory work greatly predominates over lectures, these being intended merely to supplement and systematize the knowledge gained in practical study. During the first term of the sophomore year botany is continued, 12 hours weekly being given to the study of special groups of plants, both cryptogams and phænogams, attention being also given to vegetable histology.

Zoölogy is taken up in the second term of the sophomore year and continues through the third. This consists of laboratory work supplemented by lectures and recitations. Additional work in either botany or zoölogy may be undertaken by students who are qualified to take up special work of an advanced character.

The laboratory is not as fully equipped as is desirable. It contains a number of microscopes of good quality, but little else. A new building is in course of erection, and when finished will be equipped with reference to advanced as well as elementary work. Laboratory work is now required of all students taking the general biology course, while science students must devote two terms to laboratory work subsequent to this time. They may at their pleasure devote both terms to either botany or zoölogy, or may combine them, working half the full time in each.

For admission to the freshman class the student must stand examinations in physics, chemistry, and physical geography and botany, including a knowledge of the principal flowering plants. The necessary preliminary instruction is furnished by the schools in five or six of the leading cities of the State, but students are not admitted upon certificates from these schools.

BETHEL COLLEGE.

RUSSELLVILLE, KY.

The work in biology is here limited to a course of recitations in comparative zoölogy illustrated by a few specimens. This course continues through the second half of the freshman year, but is only required of students taking a scientific course. Five hours weekly are devoted to this work.

No laboratory equipment is provided, and no acquaintance with other branches of science is required as a preliminary to this work. A brief preliminary course in physiology is provided but not required.

THE BROOKLYN INSTITUTE LABORATORY OF BIOLOGICAL RESEARCH.

COLD SPRING HARBOR, LONG ISLAND.

This laboratory is open to students from July to September, and beginners are received as well as advanced students and investigators. The courses of instruction are given by 16 lecturers, each of whom directs the laboratory work bearing upon his special topic. The location is such as to furnish abundant material, both animal and vegetable, for illustrating the lecture courses, and for the laboratory work in connection with them, as well as for research.

The building used as a laboratory is the property of the New York State fish commission, and their entire collecting outfit, consisting of rowboats, a steam launch, and a sailboat, together with the necessary dredges, nets, etc., are at the disposal of students. The equipment is ample to meet the requirements of 25 students, no more than that number being admitted.

No advanced courses are offered, investigation being entirely individual. A general course of instruction is provided with special reference to the acquirement of proper methods for work. Instruction is given in the use of the microscope, section cutting, staining and mounting, dissecting, etc., after which the student devotes his time to the practical study of a series of animals, beginning with the simplest forms and leading up to the most complex.

BOWDOIN COLLEGE.

BRUNSWICK, ME.

The course offered in biology is divided into three parts, all of which are elective. The first course, which occupies one-third of the sophomore year, is largely devoted to the study of the structure and functions of plants, but begins with a study of both animal and vegetable cells, in order to show the general properties of living matter, and the principles of general biology. The second course runs through the junior year and consists in the detailed examination of a number of animal forms, including representatives of the highest and lowest classes. With this as a basis the student undertakes the study of animals in respect to their general structure, development, and systematic relations, paying special attention during the last third of the year to the anatomy and physiology of mammals. The third course occupies the senior year and is specially adapted to those students intending afterwards to study medicine or become teachers. It includes work mainly in practical physiology and histology.

In all of these courses the time is divided between class-room and laboratory work, 2 hours weekly being given to the former. Most of the work is based upon a text-book, but frequent lectures are added. From 4 to 8 hours weekly are devoted to laboratory work, which is required of all students taking any of the courses.

The laboratory equipment is sufficient to give each student a fairly complete outfit for microscopic work as well as dissecting, and there is besides some physiological apparatus. The laboratory is fitted with tables and cases, and supplied with aquaria and other conveniences. It has been fitted with no special reference to advanced work, but some original investigations are usually in progress by post-graduate students, generally upon the anatomy or embryology of marine forms found near the college.

For admission to the freshman class no requirements in science are made. Few, if any, of the preparatory schools of the State furnish a course that would be regarded as sufficient.

BROWN UNIVERSITY.

PROVIDENCE, R. I.

No scientific knowledge is required of applicants for admission to any of the freshman courses. An elementary course in botany is offered in the freshman year as an elective to candidates for the degree of bachelor of philosophy. Through the sophomore year a course in elementary botany, occupying 3 hours per week, is open as an elective to all students, followed by a more advanced course continuing through the junior year. A course in zoölogy consisting of three lectures and three laboratory exercises per week is offered during the second half of the junior year. A course in agricultural zoölogy is required in the senior year of students on State scholarships.

The elementary work in botany consists of a general study of vegetable morphology and physiology with practice in plant analysis, instruction being given by lectures and field excursions. Each student is required to prepare a small herbarium. In the advanced courses the work consists in the study of special families of flowering plants, together with a more detailed course in vegetable physiology, histology, and geographical botany.

The course in zoölogy is designed for the general student, the lectures presenting the general principles of biology, the laws of animal morphology, the relation of animals to the world about them, etc. The laboratory work required in connection with this course is a practical study of the most important types of the animal kingdom. The time is equally divided between vertebrates and invertebrates, beginning with the latter, and each student is required to make his own dissections and drawings. At the end of the course considerable time is devoted to anthropology. The course in economic zoölogy is a consideration of the charac-

teristics of the most approved breeds of domestic animals. The study of injurious insects also receives attention.

Brown University has made no provision for laboratory equipment in biology, such as is possessed by other departments of science, and no laboratory facilities for special advanced work are provided. It possesses a valuable museum, illustrating the departments of zoölogy, botany, ethnology, etc. The zoölogical collection is arranged specially for teaching rather than for exhibition; but, in addition to the synoptic collection, there is a local collection representing the fauna of the State. The herbarium is large and of great value, including a collection of ferns of unusual size. The museum contains also large collections of native and exotic woods. A botanical garden greatly aids the work of teaching in that department.

BRYN MAWR COLLEGE.

BRYN MAWR, PA.

For entrance to Bryn Mawr College an elementary knowledge of one science is required. This may be physics, chemistry, botany, or physiology.

All of the undergraduate courses are elective, but combined in groups leading to the same degree. No student is graduated who has not pursued one scientific study through two years, devoting to it at least 5 hours weekly, or two scientific courses each of one year's length.

The courses in biology are open only to those who have had some preliminary training in chemistry and physics. The time spent in this work is uniformly 5 hours, devoted to lectures and class exercises, and 6 hours laboratory work each week. The entire course occupies 3 years, the first being taken up with an introductory comparative study of living things. General biology: In this, attention is first directed especially to the lower forms of life, the relations of plants to animals, and the general principles of the subject. After this, attention is devoted rather to the higher forms of animal life with special reference to physiology. Great stress is laid upon the fundamental facts of comparative morphology and physiology, as illustrated by the thorough study of a few types, rather than on the minutiae of classification. At the conclusion of the first year's work is a thorough study of the embryology of the chick.

During the first half of the second year 3 hours weekly are given to general zoölogy and 2 hours to the comparative anatomy of vertebrates. In the former course the more important facts in general morphology are systematically presented with special reference to the relationships and classification of animals. The course in comparative anatomy is designed to serve as an introduction to the subject of vertebrate homology, and to prepare students for the subsequent study of physiology. Six hours weekly are devoted to laboratory work bearing on these subjects.

During the second half of the session a course is offered in physiology and histology, in which detailed accounts are given of the microscopic structure and mode of action of the various organs of the animal body, accompanied by practical work in histology, and physiological experiments and demonstrations.

During the third year, a lecture course of 3 hours weekly is given, in which the student is familiarized with certain of the theoretical questions of biology. This course is partly historical, considering the order of discovery and the development of the leading generalizations of the science, and partly critical, considering such matters as the theory of evolution, the questions of heredity, variation, adaptation, metamorphosis, etc.

To students who have completed the undergraduate work above indicated, opportunities are offered for advanced work in comparative anatomy, physiology, and embryology. This work is special in its nature and consists mainly of practical work in the laboratory.

The laboratory equipment is unusually good. Five rooms, specially planned for the purpose, are devoted to the uses of the biological department. The supply of microscopes and accessories is ample, and in addition there is a liberal supply of apparatus for the study of experimental physiology.

BUCHTEL COLLEGE.

AKRON, OHIO.

The study of biology begins in the first term of the freshman year with an elementary course in zoölogy, followed in the third term by a course in botany. Three hours weekly are given to these courses, and they are so conducted as to be almost limited to subjects in which the students can collect their own material for study.

In the third term of the sophomore class there is offered a course in vegetable physiology and histology occupying 4 hours weekly, followed in the first term of the junior year by a general course in biology, to which the same time is given. In the second term of the senior class a course is given in histology and comparative anatomy, occupying also 4 hours per week.

In all of these courses text-books are little used, instruction being given by occasional brief lectures and practical exercises. The time given to practical work is more than double that devoted to lectures.

Special emphasis is laid upon the acquiring of a knowledge of the flora and fauna of the locality of the college. Students are required to make collections of plants and animals, and to study, classify, and preserve them. The insects and mollusca have been collected with especial care. The work of the year is submitted to a committee appointed from the class, and the best of it is selected by them for exhibition at commencement.

The equipment for practical work is fairly good, microscopes and accessories being provided in considerable abundance. No provision is made for special advanced work, and no advanced courses are offered, but in the elementary work the effort is made to put the student as far as possible in the position of an original investigator.

The museum is of considerable size, selected and arranged with reference to convenience in teaching rather than exhibition. It consists of a general collection illustrating the animal and vegetable kingdoms as a whole, and in addition a considerable local collection designed to illustrate the flora and fauna of the region in which the college is situated. This latter is being constantly enlarged by the work of students.

Candidates for admission to the classical course of Buchtel College are not required to offer any science for examination. Those applying for the philosophical course must have an elementary knowledge of physiology and physical geography, while those wishing to enter the scientific course must, in addition to the above, be examined in elementary physics. The college has its own preparatory department, and the requisite scientific knowledge is also furnished by the high schools of the State.

CARLETON COLLEGE.

NORTHFIELD, MINN.

Instruction in biology begins in the freshman year with a general biology course, consisting of lectures and laboratory work, occupying 75 hours during the first term and 50 hours during the second. This course is designed to introduce the student to the study of living things, with the technical methods involved in such study, passing then to the more detailed consideration of a series of animal types. Following this is a course in elementary botany, open to freshmen of the scientific course and sophomores of the classical course.

In the third term of the sophomore year two courses are offered to students of the scientific department—one in histological botany, the other in vertebrate zoölogy. One of these must be chosen. In the first term of the junior year the student is likewise allowed to elect between cryptogamic botany and invertebrate zoölogy.

A course in physiology, occupying 37 hours, is given in the first term of the junior year, most attention being given to the working of the animal body in health. In connection with this, a laboratory course in histology is given of sufficient scope to enable the student to identify the principal forms of normal tissue.

The laboratory is well suited for the work done. It contains thirty compound and fifteen dissecting microscopes in addition to all necessary apparatus for histological work. Laboratory work is made prominent in all courses, attendance being required of all students. No special arrangements are made for advanced research.

The museum contains a valuable synoptical collection, there being at least one specimen from each natural order of animals. In addition, it contains numerous glass models of forms not easily preserved. Besides these, there is a collection of birds fully representing all the forms found in Minnesota, and collections of large mammals, corals, and shells. A small herbarium has also been gotten together by the efforts of students.

Candidates for admission to the classical course are expected to have an elementary knowledge of physics, while those entering the literary or scientific courses are, in addition, examined upon anatomy and physiology. The requisite instruction is given in the preparatory department of Carleton College, as well as in the "first-class" high schools of the State and many of the academies. Students coming from such institutions are admitted to the freshman class without examination.

CENTRAL WESLEYAN COLLEGE.

WARRENTON, Mo.

In the preparatory course elementary physiology is taught, that being the only scientific study required for admission to the freshman class. This subject is resumed in the second term of the freshman year and continued through the year. The sophomore year is equally divided between zoölogy and botany, there being daily recitations in each.

This work is required of both classical and scientific students, and constitutes the only biological course offered. No laboratory is provided, and little practical work is required. The college possesses a considerable number of zoölogical specimens, also numerous skeletons and charts. It possesses also a herbarium of moderate size.

CLARK UNIVERSITY.

WORCESTER, MASS.

This institution occupies a unique place among the educational institutions of the country, the leading feature being that there are no undergraduate courses, the work being limited to original research. The methods of instruction are so planned as to supply the needs of investigators, and in general resemble the methods used in the German universities. It is especially to be noted that lectures have only a subordinate place, and laboratories and seminaries receive special emphasis. The endeavor is made in all departments to bring student and professor together on intimate terms. The teaching force in each department is sufficiently large to prevent any one member from being overburdened with the labor of teaching. There is, therefore, abundant time for that individual instruction necessary in the character of work there carried on.

Although but one session has been completed, the equipment for practical work has been provided on an elaborate scale. The general

morphological laboratory is, a large room, well lighted from the north side and well adapted to microscopical research. It is furnished with large and commodious worktables made from specially prepared designs, and with all the reagents, glassware, drawing materials, etc., required in special work. The microscopes are made by Zeiss, and furnished with full sets of his apochromatic lenses and compensating eyepieces. Dissecting microscopes of the Zeiss-Mayer pattern, Thoma & Jung microtomes, water baths, and other appliances necessary in biological investigation have also been supplied.

Five large aquaria, the largest being 8 feet in length, have been placed in the laboratory. These are supplied with running water, making it possible to keep on hand during the winter a supply of material for study and investigation. Smaller glass aquaria, also supplied with running water, afford opportunity for the rearing of special forms which are to be kept isolated.

The lecture room, adjoining the main laboratory, is of convenient size, and is supplied with a full set of Leuckart and Nitsche's zoological charts, with a complete set of charts illustrating vertebrate embryology, and with Ziegler's anatomical and embryological wax models. The nucleus of a collection of preserved specimens for lecture illustrations has been provided, and a large number of specimens have been ordered from the Naples zoological station, which, with those already obtained, will form a collection containing representatives of all the principal groups of animals.

Four other rooms assigned to this department serve as private laboratories for members of the staff.

A large room in the main building has been fitted up as an anatomical laboratory. It contains microscopes, microtomes, apparatus for injecting and modeling, incubators, and all other apparatus required for histological and embryological research.

The physiological laboratory consists of two large rooms, the one lighted by seven windows on the north, the other by seven windows on the south side. In addition to these, there is a room devoted to photography. There is an ample supply of gas and water, hoods and sinks. The furniture is solid, and well suited to its purpose. It consists of cases for apparatus and the multitude of small articles which are essential to every laboratory devoted to research; tables of various sizes and shapes which are bracketed to the walls, and hence freed from floor vibrations, and various articles designed for special use.

The laboratory is well equipped with apparatus and instruments designed to measure and record physiological phenomena. Every piece was selected solely with reference to its usefulness in research work. In addition to these there is an excellent supply of tools for working metals, wood, and glass. The character of the apparatus to be provided will depend upon the nature of the work undertaken. It is the intention to supply, as far as possible, every facility for research.

Of the greatest importance in the work of investigation is the biological club, which has been organized for the promotion of that important order of scientific activity which is dependent upon the coöperative action of a number of specialists. Papers upon topics of general and special interest are presented before the club, and a general discussion follows. The special advantage of such an organization is that investigators who have their attention specially concentrated on one line of work may keep informed of the progress of discovery and thought in other branches of research.

The courses of lectures delivered vary from year to year, and can only be described in general terms. Two historical courses are at present offered. One deals with the subject of generation, being intended to set forth the more important part of biological philosophy from the days of Aristotle up to the present. The other is devoted to the history of comparative anatomy, and aims at showing how it started as subordinate to physiology, but finally became an independent branch of zoölogy with aims and methods of its own. A third course devoted to comparative embryology will occupy 2 or 3 years, and treat exhaustively the entire subject. A course is also offered in which attention is given to special groups of coelenterates.

In vertebrate anatomy lectures are given upon the structure of organs arising from the endoderm. A course is also offered in comparative osteology, and in addition a practical course in histology.

In physiology a practical laboratory course is offered for the special benefit of those having a theoretical knowledge of physiology but lacking practical training. Short lecture courses devoted to special subjects are delivered by the professor and advanced students.

In connection with Clark University should be mentioned the "Journal of Morphology," which is there edited. Although it is open to all biological workers, and is not sustained by the university, it furnishes a medium for the publication of all valuable work there completed. It is especially devoted to the presentation of original research in embryology, anatomy, and histology, and is noteworthy as being the only journal of this character in the country.

COLBY UNIVERSITY.

WATERVILLE, ME.

The biological work of the entire course consists of a 7-weeks' course in botany, a course of 10 weeks in physiology, and a course in comparative zoölogy to which 4 weeks are devoted. The course in botany begins in the third term of the sophomore year and includes daily recitations in structural botany with a few lectures devoted to cell structure. In connection with this, about 3 hours weekly are devoted to laboratory work, principally plant analysis. Physiology is taken up in the second term of the junior year. A few lectures are devoted to the

general aspects of physiology, but most of the time is taken up in recitations from a text-book. The comparative zoölogy is merely introductory to paleontology. It consists of lectures and recitations in the third term of the senior year.

No adequate provisions have been made for biological teaching. There is no separate professorship, the work being for the present under the charge of the professor of geology. It is expected that this will all be changed within one or two years.

COLGATE UNIVERSITY.

HAMILTON, N. Y.

Students are admitted to the scientific course on standing an examination in elementary chemistry and physics. The necessary scientific training may be obtained at most of the high schools of the State, students from a number of these being admitted without examination on presentation of certificates.

Zoölogy is offered as an elective in the first term of the junior year, the characteristics of the subkingdoms, classes, and orders being presented by an extensive study of type specimens. Botany is elective in the third term of the senior year, most of the time being devoted to practical field and laboratory work. Each course requires 2 hours daily during the time it is in progress. An elective course in physiology is offered occupying two terms of the junior year. This course consists of daily lectures supplemented by illustrations and demonstrations.

A biological laboratory has lately been equipped with compound and dissecting microscopes, histological appliances, aquaria, etc., selected with special reference to the needs of students in elementary courses, no provision having been made for advanced work. The museum contains a large number of invertebrate specimens, being especially rich in corals and shells. There is also a collection of birds of unusually large size, and a considerable herbarium.

COLLEGE OF THE HOLY CROSS.

WORCESTER, MASS.

No course in biology is offered.

COLLEGE OF NEW JERSEY.

PRINCETON, N. J.

The courses in biology are required of all students of the freshman and sophomore years of the academic department. Beyond this they are elective. The first subject considered is human physiology, which occupies 1 hour weekly during the second half of the freshman year. During the second half of the sophomore year a course occupying 2 hours weekly is given in zoölogy and botany, the general principles of

classification, methods of investigation, and general laws illustrated by animal morphology being first considered, after which is a series of recitations in botany accompanied by practical work in the examination of plants.

Students in the general scientific department are required to follow the above-mentioned courses in physiology and zoölogy. They are further required to follow a course in botany consisting of seventy-two exercises of 2 hours each. These are exclusively practical, including the examination of plants as to their morphology, histology, modes of development, and physiology. Text-books are but little used, students being instructed in the methods of microscopical examination and then expected to acquire the characters of the principal orders of plants from a study of representatives of those orders.

The junior course, which is elective to academic students but required of those in the scientific course, consists of work in general biology, occupying 1 lecture hour and 2 laboratory hours weekly. During the first half-year vegetable and invertebrate animal types are considered, after which attention is given to vertebrate morphology, including a course of vertebrate dissection.

A course is offered in histology occupying one afternoon each week during the second half-year. This course is required of sophomores in the general scientific course, and is elective to juniors and seniors in the academic department. It consists of lectures and demonstrations, with laboratory work in microscopic anatomy. The most approved methods of injecting, hardening, staining, and mounting specimens are taught, and these methods are applied to the study of the principal tissues taken from the human body and lower animals.

A special scientific course is planned for those intending to study medicine. In it biology and chemistry receive considerable attention. The special studies of the course begin in the second half of the junior year, being a continuation of the work of the first half-year required in the general course. Lectures, with accompanying laboratory work, are given upon special topics in comparative anatomy, while the senior year is devoted to mammalian dissection and advanced embryology.

Advanced courses in all the subjects mentioned are arranged for those wishing to apply for a higher degree. They are sufficiently elastic to meet special needs, being intended for those wishing to carry on original research or to prepare themselves for teachers.

The biological laboratory has been recently erected, being a gift to the college from the class of 1877. It is designed for advanced practical and experimental courses in anatomy, embryology, and physiological psychology. The main laboratory, occupying the greater part of the second floor, is equipped for the instruction of undergraduate students, while the first floor contains laboratories for research in embryology and psychology; in the basement are aquaria and other arrangements for storing live animals. In another building the laboratory for

histological work is situated. It contains microscopes and appliances for 22 students, and in addition there is a large collection of slides, to which they have access.

The museum contains a considerable number of specimens of invertebrates, illustrating the principal groups. Among the vertebrate collections are a large number of skeletons of mammals, reptiles, birds, and fishes, and in addition a full series of the birds of New Jersey and other districts of North America. In the same building is arranged a large herbarium, classified according to Bentham and Hooker, and including a large part of the flora of the United States, and many specimens from all parts of the world.

THE COLORADO AGRICULTURAL COLLEGE.

FORT COLLINS, COLO.

Two courses of instruction are here offered—one agricultural, the other mechanical—both being alike up to the beginning of the junior year.

The study of vegetable life begins in the freshman year, 25 weeks being given to recitations and the practical study of plants. Each student is required to prepare a small herbarium, and to make drawings and descriptions of the plants studied.

In the sophomore year a course of daily recitations and lectures in human anatomy and physiology is given. This occupies one term, and is illustrated by models and demonstrations.

In the first term of the junior year zoölogy is begun, the course consisting of daily lectures and practice in making dissections and drawings of selected animal forms. During the second term a course is offered in vegetable physiology and histology, in which part of the time is devoted to cryptogamic botany, especially molds, rusts, and mildews. This course is largely practical, consisting of lectures and 2 hours of daily work in the laboratory. Entomology is taken up in the third term of the junior year, the course consisting mainly of laboratory work, and attention being given especially to insects injurious to vegetation. Students are required to collect, classify, and mount their own specimens.

In the senior year of the agricultural course veterinary science is taken up during one term. In connection with this is a laboratory course in animal histology, instruction being given in the methods of hardening, cutting, and staining tissues and in the use of the microscope.

In all of the courses mentioned laboratory work is strongly emphasized. In each there is a daily recitation, in which some practical work may be done, and in addition 2 hours daily are spent in the laboratory.

A new laboratory, specially arranged for botanical work, has just been completed. It contains a large class laboratory, a private laboratory

for the professor's use, a room for advanced work for students, a photograph room, storerooms, etc. The equipment of this building is ample for the elementary work, and, in addition to this, opportunities for research are given to all students qualified to undertake it. Rooms are provided in another building for the study of entomology, breeding cages being provided in abundance, and other appliances for observing the habits and metamorphoses of insects.

No knowledge of science is required of applicants for admission, but such a knowledge as may be obtained in most of the schools of the State found in towns of 2,000 population and over has been found beneficial and is strongly recommended.

COLUMBIA COLLEGE.*

NEW YORK CITY.

Candidates for admission to the freshman class are not examined in any scientific subject.

In the arts course botany is the only biological subject presented, and this is elective to juniors and seniors. The course consists of lectures throughout one year, accompanied by parallel reading, but no laboratory work. It is conducted in connection with the department of geology. No provisions are made for biological work in the graduate department.

For admission to the school of mines an elementary knowledge of physics and chemistry is required.

In each of the seven courses here offered botany is required in the first year and zoölogy in the second. These courses are conducted by means of lectures and text-books, but without laboratory work. In the course in geology, botany is continued throughout the entire four years. The first year being devoted to general botany, the subject of vegetable histology and cryptogamic botany are taken up in the second, and continued into the third, the fourth year being occupied with economic and palæo-botany. Zoölogy is likewise continued in this course through the third and fourth years, protozoa being practically studied in the second year, coelenterates, echinoderms, and mollusks in the third, while the remaining subjects are taken up in the fourth. During the second year a course consisting of four weekly laboratory exercises is given in the use of the microscope. In this course special reference is had to hygienic and other practical applications, the student being occupied in the study of food products, textile fibers, micro-chemistry, toxicology, etc. This course is followed in the third year by a course in biology, with special reference to the study of bacteria

* This statement was based mainly upon the catalogue for 1889-90. The department has recently changed hands and extensive changes will soon be introduced, but at the time of going to press (September, 1891) it is impossible to give their extent.

in relation to sanitary questions. Laboratory work is greatly emphasized, and the lectures upon any given subject always follow the kindred laboratory work, no text-book being used.

In the course in chemistry the biological work consists of botany and zoölogy in the freshman and sophomore years, respectively, and in addition, microscopy in the sophomore year and biology in the junior, the courses being the same as above given. In the course in sanitary engineering the work is the same, except that biology is omitted for the junior year.

Separate laboratories are provided for microscopy and bacteriology, and facilities are also provided in abundance for photographic work.

CORNELL UNIVERSITY.

ITHACA, N. Y.

For admission to any of the undergraduate courses, candidates must pass an examination in elementary physiology, no other scientific subject being required. Students may be relieved from this examination on presenting a regents' diploma or a certificate from an accredited school.

Four general courses are provided, leading, respectively, to the degrees bachelor of arts, bachelor of philosophy, bachelor of letters, and bachelor of science. In all of these the work of the freshman year is prescribed, a part of the sophomore work is elective, while in the junior and senior years students are entirely free to select their own studies. They are urged to choose their sophomore studies with reference to the work of the junior and senior years, and great freedom is allowed to enable those courses to be selected which have the most direct bearing upon the future life of the student.

In all the general courses a brief course in hygiene, occupying 1 hour weekly during one term, is prescribed in the freshman year, while during the sophomore year there is a course in physiology, consisting of thirty-one lectures accompanied by demonstrations and practical exercises. The elective work of the bachelor of arts course is without restriction, as is also the case in that leading to the degree bachelor of philosophy. In the course leading to bachelor of letters 9 hours weekly must be devoted to literary, historical, and philosophical subjects, and in the general scientific course the same time must be devoted to scientific subjects. A special degree of bachelor of science in natural history is given to those students who choose all their electives from the biological courses and show sufficient knowledge of Latin and Greek to enable them to analyze ordinary scientific terms.

The biological studies which may be elected are the same in all courses. Usually a definite order is recommended, but this is of necessity somewhat flexible.

The biological courses are presented in three divisions—botany, vertebrate anatomy and physiology, and entomology and invertebrate zoölogy, each under the charge of a professor with one or more associates or assistants.

The courses in botany begin with a general introductory course occupying one term and consisting of two or three weekly exercises with recitations or practical work. Students who have completed this course may take a course in systematic and economic botany, in which the classification of the vegetable kingdom is first taken up with special reference to the orders *compositæ* and *graminæ* during the first term. In the winter term other natural orders and groups of economic plants are studied, while the spring term is devoted to a more detailed study of the structure, affinity, distribution, and economy of some one natural order. A course devoted to vegetable histology consisting of one lecture and 2 hours' laboratory work is given during one term, while a course of about the same length is given in the study of fungi. Those wishing to do so, and properly qualified, may take up the special study of various groups of cryptogams. One lecture weekly is usually given during one term, the subject chosen varying from year to year. Short special courses are also given in forestry and arboriculture, in pharmaceutical botany, and in the study of exotic plants, with practical greenhouse work. In addition to these, facilities are afforded to all students properly qualified to take up advanced laboratory work, and to devote attention to special investigations of phænogams and vegetable physiology, or to cryptogams and vegetable histology.

In the department of vertebrate anatomy and physiology there is given, first, a course in vertebrate zoölogy supplementary to the course in physiology required in the sophomore year. This consists of twenty lectures and ten practical exercises during one term. A laboratory course, occupying 3 hours weekly through the year, is devoted to the subject of gross anatomy, histology, and embryology, one term to each, and the continuation of these introductory courses is found in a laboratory course, consisting of daily work in comparative anatomy or vertebrate zoölogy, and a similar course in histology. In these the work is of an advanced character, and is suited to meet individual needs. A course of eighteen lectures on the morphology of the brain, accompanied by demonstrations, should also be mentioned.

In invertebrate zoölogy there is given a general course, consisting of three exercises weekly, either lectures or laboratory work, while an additional laboratory course, consisting of daily work during two terms, is also given. During one term two lectures weekly are devoted to the subject of entomology, attention being given to the orders, suborders, and more important families, with special reference to those of economic importance. Opportunities are afforded for daily laboratory work in the study of the anatomy or life history of insects, as well as in the determination of species.

A special course leading to the degree bachelor of science in agriculture is given. In this, the biological work is mainly selected from the courses already mentioned. Zoölogy and botany with practical work are required in the sophomore year, the other studies being elective, with only this restriction, that 12 hours weekly be devoted to subjects directly related to agriculture.

The university possesses abundant accommodations for laboratory work in connection with the courses given. The anatomical laboratory contains all instruments and materials needed in the practical work in anatomy, histology and embryology, and physiology, while the laboratories for botany and invertebrate zoölogy are equipped with equal completeness.

Several special museums serve to illustrate the work of the biological department. The botanical museum contains the herbarium estimated to contain 15,000 specimens. In addition, there are large collections of fruits, seeds, fibers, and other economic products, and more than 1,000 specimens of woods. There are also many teaching appliances—wall maps, charts, models, lantern slides, etc. The large conservatories and gardens, and the rich native flora should also be mentioned in this connection as affording abundant material for laboratory work. The museum of entomology and invertebrate zoölogy contains a series of forms selected to represent nearly all the larger invertebrate groups, and found in all parts of the world. The collection of insects includes all the more common species of the northeastern United States, and there are also many sets of preparations illustrating the metamorphoses and life histories of insects. A special room is devoted to the collection of shells, including more than 80,000 specimens and about 15,000 species. Of special value in relation to the agricultural course is the veterinary museum, which contains numerous skeletons of domestic animals, and models illustrating their normal anatomy, as well as many of the alterations in parts due to disease.

The museum of general zoölogy, in which all the vertebrate specimens are placed, contains about 3,500 entire animals in alcohol, representing 2,400 species. Of these, about one-half are fishes, and the others include representatives of the general North American fauna, and numerous rare forms from all over the world. There are also about 2,800 preparations, including skeletons and dissections of various animals, and about 600 illustrating the brain structures of the various animal groups. In addition, there are about 1,100 mounted skins, many of them rare forms, and about 900 microscopical preparations, besides numerous models illustrating special points in vertebrate anatomy. All of these collections are so arranged as to exemplify certain morphological ideas, as for example, the unity of general structure under diversity of form within the limit of a class, the resemblances between different classes, the existence of apparently useless organs, etc.

DARTMOUTH COLLEGE.

HANOVER, N. H.

Candidates for admission to the scientific course are examined in physical geography. Other candidates are not subject to examination in any scientific study.

A course of six lectures in hygiene is given at the beginning of the freshman year, after which are courses in physiology and botany required of students taking the scientific course. These students are also required to follow a practical course in biology, thirty-seven exercises of 2 hours each being devoted to the invertebrates in the sophomore, a like number being devoted to the vertebrates in the junior year. A course of thirty-six lectures in general zoölogy is given in the junior year, and is open to all students. This constitutes the entire biological work required of students in the classical course. A course of fifteen lectures in anthropology is offered in the senior year.

The laboratory is supplied with microscopes and the usual accessories, one being allowed for each two students. No provision is made for work of an advanced character. Attendance is required only of students in the scientific course.

In the Chandler School of Science and Arts candidates for admission are examined in physical geography and physiology. The biological work of the course begins with systematic botany, which is taught during two terms of the freshman year, 4 hours weekly being devoted to recitations and practical exercises. Each student is required to prepare a herbarium of 100 specimens, but this number is often greatly exceeded, owing to the fact that a prize is offered for the best herbarium, and all are exhibited at commencement.

During the first term of the sophomore year a course is given in structural and physiological botany. This occupies 36 hours, and is designed to give the student an outline of the entire vegetable kingdom. A course in zoölogy, occupying 36 hours, is given in the latter part of the sophomore year. This is accompanied by demonstrations, making use of such illustrative material as may be available.

These courses are required of all students in the school of science. No laboratory work is done, and no provisions are made for it.

Students are admitted to both Dartmouth College and the Chandler School of Science from many of the high schools of the State without examination, the necessary scientific preparation being given by such institutions.

DAVIDSON COLLEGE.

DAVIDSON COLLEGE, N. C.

The only biological work done is in the senior year, when a short course of lectures is given in botany and zoölogy preparatory to the course in historical geology. No practical work is done in connection with this.

DENISON UNIVERSITY.

GRANVILLE, OHIO.

In the classical course the work in biology begins with a course in physiology, occupying 4 hours per week during the second term of the sophomore year, this course being preceded by a course in chemistry in the freshman year, of which laboratory work forms a required part. In the third term a course in botany is given, consisting of systematic and physiological botany. In the junior class a course of lectures and laboratory work occupying 8 weeks is given on invertebrate zoölogy.

In the scientific course biology begins in the sophomore year with a course in comparative anatomy and dissection, lasting through one term, followed by a laboratory course in cryptogamic botany in the third term of the same year. Courses in general zoölogy and histology, each occupying one term, are offered in the junior year. The former is devoted mainly to invertebrates, beginning with unicellular forms and leading up to the vertebrates. In the latter course opportunities are given for a certain amount of special individual work.

The laboratory is fairly well provided with compound and dissecting microscopes, microtomes, etc., with the usual accessories, and a series of skeletons, casts, slides, etc., illustrating the teaching of physiology. There is no physiological apparatus yet provided, but this need will soon be supplied. For botany a herbarium of considerable size affords the necessary illustrative material.

In the equipment of the laboratory no special arrangement for advanced work has been made and no advanced courses of instruction are offered. A certain amount of research is made, however, by instructors and advanced students, and the results are published in the "Bulletin of the Scientific Laboratories of Denison University." Four volumes of this series have been completed, being made up in part of papers dealing with the local natural history and geology, but also including numerous papers of general interest.

Students completing the course at Granville Academy are passed into the college without examination. The science there taught includes elementary physics, chemistry, physiology, and botany. Students coming from other institutions must be examined on the same subjects.

DE PAUW UNIVERSITY.

GREENCASTLE, IND.

Students applying for admission are expected to have an elementary knowledge of physiology and physics. Those who apply for the degree of bachelor of science may, instead of German, offer two scientific subjects, botany and zoölogy among others, only an elementary knowledge being expected.

In the arrangement of courses leading to degrees the four-class plan is followed, though the studies for each year are not strictly prescribed.

The degrees offered are bachelor of arts, bachelor of science, and bachelor of philosophy. The studies leading to each are selected by the student under certain general restrictions, it being required that every student finish one major study and one minor study for any degree, in addition to its special requirement. To complete a major study, 4 hours weekly during 2½ years are necessary, a minor study occupying the same time during 1½ years. Upon the choice of subjects depends the degree received.

Under this plan it is possible for the undergraduate who is so disposed to devote attention to biology during 2½ years, or to select portions of the work offered at pleasure. Any one of the biological courses consists of four lectures weekly and 6 hours' laboratory work. A course is first given in general zoölogy, in which attention is first given to the invertebrates, passing then to the vertebrates, and finally to the subject of embryology. As a natural sequence to this is a course lasting through one year, in which the subjects of mammalian anatomy, physiology, and histology are considered. To students who have completed these courses opportunities are afforded to follow more advanced courses in physiology, embryology, vertebrate anatomy, and ichthyology. Students who so desire may elect botany as a part of either the major or minor course, devoting attention first to structural and systematic botany, and during a succeeding semester pursuing the study of vegetable physiology.

These are offered as undergraduate courses, and it is for these especially that the department is equipped. Opportunities for graduate work are afforded in addition, schemes being arranged for each student in accordance with his own special tastes.

The laboratory contains thirty-seven compound microscopes, and a sufficient number of microtomes and other pieces of apparatus. For physiological work considerable provision has been made, and there is abundant apparatus for the study of muscle and nerve physiology, as well as the physiology of the heart and special senses. In addition there is the usual recording and time-marking apparatus. For use in the anatomical courses there are abundant models and skeletons, as well as dissecting and injecting apparatus.

The museum is especially rich in its collections of fishes, but includes also many insects and birds, as well as a general collection of invertebrates. Among the botanical collection may be mentioned a set of the plants of Indiana, and a set of De Thurmen's *Mycotheca universalis*.

EARLHAM COLLEGE.

RICHMOND, IND.

Students applying for admission are required to pass satisfactory examinations in physiology and botany. Those coming from a number of approved high schools are admitted without examination, the necessary scientific instructions being given by most of the schools of the State.

The introduction to scientific work in the college course is furnished by chemistry, which comes in the second term of the freshman year, followed in the third term by a course in general biology. To this course 10 hours weekly are given, there being one lecture and one recitation per week, the rest of the time being given to laboratory work. This course consists mainly of cryptogamic botany, which is begun with a study of the simplest forms, continuing through representatives of intermediate groups up to the phanerogams. A course of twenty lectures on comparative anatomy is given to the sophomore class. These lectures have special reference to subsequent work in geology, and are fully illustrated by abundant specimens.

An additional course in biology may be elected in the junior year, 10 hours weekly being given to it, as in the freshman class. In this course a certain amount of latitude is allowed, students selecting at will special lines of work in either botany or zoölogy.

The arrangements for laboratory work are ample. Special rooms are provided for advanced work, and the general laboratory is well stocked with the usual apparatus, chemicals, etc., needed in connection with general work in biology.

The museum consists of a considerable number of skeletons, more than 200 stuffed birds and other animals, about 600 species of shells, and the same number of corals.

FRANKLIN COLLEGE.

FRANKLIN, IND.

A course in general biology is given in the sophomore year during two terms, followed by a course in botany in the third. In addition, there is required of scientific students a course in vertebrate anatomy, running through the entire sophomore year. Botany and zoölogy are elective through the junior year.

For entrance, an elementary knowledge of physics, zoölogy, botany, and physiology is required. This instruction is provided by the preparatory department of Franklin College, from which most of the collegiate students come. The preparatory course in zoölogy is mainly limited to the invertebrates, the sophomore course being devoted to a practical study of the vertebrates.

The botanical work of the preparatory course is devoted to the structure and classification of flowering plants. During the sophomore year the student is familiarized with some of the more common cryptogams, and is also required to prepare a herbarium of not less than 50 species. The general biology course in the sophomore year consists of a study of numerous selected types, both animal and vegetable, preliminary to the more special courses in zoölogy and botany offered in the junior year. These courses consist mainly of practical work, 6 hours weekly being used for that purpose.

Franklin College possesses no biological museum, and has but an ordinary equipment of microscopes and laboratory appliances.

FRANKLIN AND MARSHALL COLLEGE.

LANCASTER, PA.

Biology is begun in the sophomore year, zoölogy being first taken up, afterwards botany. Both of these courses are largely practical, 4 hours weekly being given to lectures and laboratory work. The work in zoölogy is the study principally of common animals taken up in any order that may be convenient. The botanical work consists of plant analysis and vegetable histology. During the entire junior year there is one weekly practical exercise in animal histology, and during the senior year embryology is studied in the same way.

The arrangements for laboratory work are primitive, there being merely appliances for the ordinary microscopic work. The college possesses a valuable herbarium, containing about 6,000 species of the phanogams and vascular cryptogams of the eastern United States.

No knowledge of any scientific study is required of applicants for admission to the freshman class of Franklin and Marshall College, and no science precedes biology in the college course except an introductory course in chemistry continuing through one term of the freshman year.

FURMAN UNIVERSITY.

GREENVILLE, S. C.

No entrance examinations are provided, and all the degrees are conferred upon the completion of elective courses.

The biological course begins with a series of recitations in general zoölogy, giving attention to the general properties of living matter, and leading up through a series of types to the vertebrates, after which the subject of classification is taken up. A course of lectures is then given in anatomy and hygiene, followed by a course in human physiology. In this are considered the general structure and mechanism of the body, and such questions as the composition and value of foods, exercise, the preservation of health, etc.

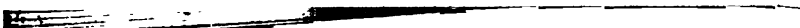
There are no laboratory facilities, a small cabinet of shells, reptiles, birds, etc., being the only aid in illustrating the subject.

GEORGETOWN COLLEGE.

GEORGETOWN, KY.

For admission to the freshman class no science is required.

The biological work of the college consists of physiology, zoölogy, and botany, the whole occupying less than 1 year. In the classical course this is in the senior year, physiology and zoölogy occupying the first term, and botany part of the second. These are preceded by chemistry, which occupies one term of the sophomore year. In the scientific course physiology and zoölogy are studied by second-year



students, while botany occupies part of the senior year, as in the classical course. These courses are conducted by text-book entirely, and no provision is made for practical work.

HAMLIN UNIVERSITY.

HAMLIN, MINN.

Students applying for admission to the scientific course are required to pass examinations in elementary physics and physiology. This instruction is furnished by the preparatory department of Hamlin University, as well as by most of the schools of the State.

No scientific work is introduced into the classical college course until the junior year, when chemistry and biology begin simultaneously. The latter consists of a course in general biology, to which is given 2 afternoons weekly through two terms, followed by a course in systematic botany, to which the same time is given. Classical students are given, in the senior year, a course of lectures and recitations in animal physiology, continuing through two terms and occupying $2\frac{1}{2}$ hours weekly. The course prescribed for scientific students is the same, with the addition of a course in zoölogy in the freshman year, to which 3 afternoons weekly are devoted. All of these courses are largely practical. The work of the freshman class is a series of studies on the invertebrates. In the junior class attention is given to cryptogamic botany and mammalian anatomy during two terms, followed in the third by a general course in morphological and physiological botany of phanerogams, including plant analysis. In connection with the course in physiology a certain amount of laboratory work in histology is prescribed.

The laboratory has no facilities except for work of a simple character. It has a limited number of microscopes and the usual accessories. Laboratory work is a required part of each course.

A museum of considerable size has been gotten together, and so arranged as to greatly facilitate the work of teaching. There has recently been added a number of mounted vertebrate skeletons, in addition to numerous smaller specimens.

HANOVER COLLEGE.

HANOVER, IND.

The biological work consists of an elementary course in the junior preparatory class. A course in botany is offered in the sophomore year, followed by a course in anatomy and physiology in the junior. There is no provision for practical work further than a small amount of microscopic work. Additional facilities will soon be provided.

HARVARD UNIVERSITY.

CAMBRIDGE, MASS.

Owing to the great freedom which is here offered students in the choice of studies, it is possible for anyone so inclined to follow a large number of different lines of biological study. The methods by which the entrance examinations are conducted insure that every student following a scientific course will have had a preliminary training in elementary science. The requirements for entrance are divided into elementary and advanced studies. All students are required to pass the elementary examinations in either physics or chemistry, and must have performed a series of experiments not less than forty in number in one of these branches. In the advanced examinations in these subjects, which prospective scientific students are expected to pass, a practical laboratory test is conducted, as well as a written examination. The candidate must also at the time of examination hand in for inspection a note-book containing the result of not less than sixty experiments in addition to the elementary requirements.

In the freshman class physics and chemistry are the only scientific subjects prescribed, and to each of these 1 hour weekly is devoted during half a year. In addition, a course may be elected by freshmen, consisting of zoölogy during the first half-year and botany during the second. In each subject 2 hours weekly are devoted to lectures and 3 hours additional are devoted to laboratory work. Both of these courses are elementary, serving as an introductory course for those wishing to go farther, and yet complete in themselves for those who wish merely a general view of the subjects.

During the remaining years of the course students may elect a course in general biology, consisting of three exercises weekly, and to those who have finished all the work above mentioned further courses in zoölogy and botany are open. To these 2 or 3 hours weekly are devoted, laboratory work being required in addition. A special course in cryptogamic botany is open to students who have taken the general course in botany and general biology. This consists of three weekly exercises during half the year with laboratory work. Half-courses are also offered in microscopic anatomy and comparative osteology, the former receiving 3 hours and the latter 1 hour weekly, and each involving laboratory work additional.

Post-graduates and undergraduates who are exceptionally well prepared may undertake, under the direction of the various instructors, special advanced work in different directions. The courses at present offered are in embryology, entomology, vegetable physiology, economic and cryptogamic botany, and paleontology.

In the Lawrence Scientific School, among the courses leading to the degree bachelor of science is one in which biology receives special attention. The individual courses in biology are the same as those above

mentioned, differing in this respect only that they are all prescribed at fixed times, the entire course occupying 4 years. Zoölogy and botany are taken up in the first, general biology and botany in the second, and zoölogy and cryptogamic botany in the third. The fourth year is devoted to research in some one of the special lines mentioned above.

There are separate workrooms provided for the department of zoölogy and cryptogamic and phænogamic botany. The last named are located at the botanical garden, the others in the museum of comparative zoölogy, considerable portions of the fourth and fifth floors being devoted to this purpose. Seventeen small laboratories are provided for the special use of advanced students engaged in a study of the museum collections. One additional laboratory is arranged for advanced work in anatomy and embryology, while there are besides three large laboratories for general class work. Each of these is well lighted and fitted for the work there performed, containing modern appliances in sufficient quantity. The entire contents of the museum of comparative zoölogy are available for the illustration of these courses, but there is a special set of embryological models, in addition to several cases of anatomical preparations specially adapted to this purpose.

The courses in cryptogamic botany are conducted in the same building, and ample provision is made both in regard to space and equipment for the work of undergraduate classes as well as special advanced students. For the former everything needed for work is provided, while of special interest to the latter are the large collections of fungi and other lower forms.

The courses in phænogamic botany and vegetable physiology are conducted at the botanical garden, where every facility is provided for them. Abundant laboratory space and all needed instruments are furnished, while the garden yields an abundance of specimens for study, about 6,000 species of flowering plants being cultivated for this purpose. Of special value to investigators is the large herbarium containing about 200,000 specimens collected from all over the world, and the botanical library, consisting of about 8,000 volumes and pamphlets, close by the herbarium and readily accessible. Special mention should also be made of the large collection of glass models of flowers, about 600 species in all, made by Blatschka. These illustrate all the important genera found in the northern United States, and furnish valuable means for lecture illustrations.

Mention should be made of the summer courses in botany, which consist of lectures upon structural botany and vegetable histology, accompanied by laboratory work.

In the Bussey Institution, a branch of Harvard at Jamaica Plain, Mass., biological work is taken up at the beginning of the course. Attention is at first given to lectures and demonstrations upon the subjects of cell structure, protoplasm, relations of animal and vegetable

tissues, etc., after which the general classification of animals is considered, the leading characters of each group being presented. Special attention is then given to insects, dissections and drawings being required illustrative not merely of the anatomy of the adult forms but of the development, including fertilization, segmentation, and later stages. The classification, habits, and general economy of insects are then considered, with special reference to the forms injurious to vegetation and the means for their extermination.

Instruction is also given in botany. This embraces the element of structural and systematic botany and the general classification of flowering plants. Abundant practice is given in plant analysis, with special reference to the needs of students of agriculture and horticulture.

Instruction in these subjects is given by lectures and practical work. One and one-quarter hours weekly are given to lectures. Every student is required to do a certain amount of laboratory work, but is not restricted in time.

The equipment for laboratory work is ample for the needs of the institution. There is abundant room for students engaged in elementary work, and in addition there are unusually good opportunities for research in entomology and the embryology of insects. Unusual facilities for botanical work are also offered in the greenhouses of the institution, as well as in the Arnold arboretum.

Students applying for admission are not subject to formal examination, but a certain amount of scientific knowledge is presupposed. It is recommended that all such students spend one year at the Lawrence Scientific School in Cambridge (which see), taking the preliminary course there provided, which includes elementary courses in chemistry, physics, biology, and geology.

HAVERFORD COLLEGE.

HAVERFORD COLLEGE, PA.

Candidates for admission to the freshman class of the classical course are not subject to entrance examination in any scientific subjects. Those applying for the scientific course must pass an examination in the elements of physics and physiology. Many of the schools of the State furnish the amount of scientific instruction required, and pupils are admitted to college without examination from all schools approved by the college.

The college course in biology begins with a course of lectures in physiology and hygiene, 2 hours weekly in the freshman year being given to this work. Scientific students are required to spend one afternoon each week in practical exercises in connection with this course. During the second half-year botany is taken up, the general subjects of vegetable morphology, physiology, and classification being considered.

The laboratory work of the classical section consists mainly in the analysis of flowering plants, while the scientific sections spend 2½ hours weekly in working through a selected series of cryptogams.

Sophomores of the scientific course have one lecture weekly in systematic zoölogy during half the year. In connection with this is a series of laboratory exercises in general biology. During the second half-year scientific sophomores are given a laboratory course in vertebrate zoölogy, the results of this work being embodied in a thesis, which takes the place of an examination.

Biology is elective in the junior and senior years. The courses there offered are a course of lectures and laboratory work in general biology, a course in invertebrate zoölogy and vegetable histology, a course in vertebrate anatomy and histology, and a course in embryology. To each of these 2 hours per week are given, the latter course occupying but half the year. All of these are undergraduate courses, open alike to classical and scientific students.

Advanced courses in comparative morphology, as well as in pathology and bacteriology, are open to post-graduate students and may be included in courses leading to the degrees of doctor of philosophy and doctor of science.

The laboratory appliances are sufficient for eighteen students doing elementary work. They consist of microscopes and the usual accessories, reagents, etc. A special laboratory is set apart for the use of students engaged in advanced work. This room is supplied with microscopes of high grade, cameras, culture and sterilizing ovens, and all the apparatus necessary for work in pathology, bacteriology, and microphotography.

As an additional aid in teaching, the college possesses a museum especially rich in birds, eggs, and shells, but containing many other zoölogical specimens. It possesses besides a considerable herbarium, mainly illustrating the local flora.

HOWARD COLLEGE.

EAST LAKE, ALA.

Biology is begun in the junior year, and attention is given first to physiology, following which are zoölogy and botany. Daily exercises are held in which instruction is given both by text-book and lectures. These are illustrated by whatever objects are available. No laboratory is provided, but probably will be in the near future. For admission to the freshman class no knowledge of science is required, there being few, if any, preparatory schools in the State that furnish acceptable courses in science.

ILLINOIS COLLEGE.

JACKSONVILLE, ILL.

Four different courses of study are pursued, with slightly different requirements for entrance. Students entering the classical course are not subject to examination in any scientific subjects. Those applying for the philosophical course are examined in zoölogy, botany, and

physiology, while those wishing to enter the scientific or agricultural courses must stand the same examinations, and in addition must have analyzed at least 50 wild plants.

In the classical and philosophical courses no work in biology is required, the first scientific subject (physics) being taken up in the sophomore year. In the classical and agricultural courses biology continues through the freshman and sophomore years, the work being nearly the same in both courses. The freshman year is devoted to botany. During the first term advanced systematic botany is pursued, special attention being given in the agricultural course to the grasses and cereals. During the second term vegetable physiology and histology are considered, while the third is devoted to cryptogamic botany, with special reference to injurious fungi. The work of the sophomore year begins with a course in general biology, with special attention to invertebrate animal forms. During the second and third terms entomology is studied in its scientific as well as economic relations.

These courses are conducted by text-books mainly, three exercises weekly being given to each course. No special laboratory is provided, only a few rooms in one of the dormitories being temporarily fitted and supplied with microscopes. Laboratory work is only required of scientific students, who devote to it 5 hours weekly.

In connection with Illinois College is the Whipple Academy, which furnishes the instruction in science requisite for admission to the college classes. This is furnished also by all the academies of the State and about half of the high schools, but students are not admitted on certificates.

ILLINOIS WESLEYAN UNIVERSITY.

BLOOMINGTON, ILL.

In the freshman class a course in physiology is offered, occupying 4 hours per week through one term. During the second term scientific students are required to attend a series of health lectures, and in the third term a course of structural botany. Zoölogy is required of all students during one term of the sophomore year, 4 hours weekly being given to it. As a preliminary to this work there are given in the preparatory department courses in elementary botany, zoölogy, and physiology. In connection with these, 2 hours weekly are spent in laboratory work. The course in physiology "has been put in the hands of a practicing physician * * * and is intended to cover the subject of physiology and health in a manner in some degree proportionate to its importance as a part of sound and practical education." This work is placed early in the course in order to impress the practical points considered upon the minds of students at as early an age as possible. Students at this stage of their course have had no training in chemistry, this subject not being taken up until the junior year.

The course in structural botany is mainly pursued in the laboratory, the preliminary training desirable being furnished by a course in systematic botany in the preparatory course. The work is largely individual, students being furnished with materials and appliances, and notes and drawings being required. The sophomore course in zoölogy is largely devoted to the study of comparative anatomy, and to the subjects of nutrition, growth, and reproduction. In this course 4 hours of laboratory work are required weekly of each student.

The laboratory facilities are fair but not equal to the demands made upon them. Two rooms are fitted up in the usual way with dissecting tables, etc., and contain in addition aquaria and other arrangements for preserving animals. There are but three compound microscopes in the laboratory equipment. The museum is of considerable size and contains many specimens of value. It consists of (1) the Vasey herbarium, containing about 2,500 species of the phanerogamia of Illinois; (2) a collection of plants from Colorado and Utah, collected by the Government surveyors; (3) miscellaneous collections, including algæ, mosses, and ferns; (4) the Holder collection of birds, numbering over 200 specimens; (5) a large collection of marine invertebrates; (6) a collection of insects; (7) a large collection of fresh-water shells; (8) miscellaneous collections, including mammals, reptiles, mounted skeletons, skulls, etc.

Most of the collegiate students enter the freshman class from the preparatory department. Certain of the schools of the State are accredited, and students are admitted from these on certificate from the principal.

INDIANA UNIVERSITY.

BLOOMINGTON, IND.

Great latitude is here allowed to students in the choice of courses leading to the degree of bachelor of arts. Certain studies are required of all, the minimum amount of scientific work being one year of daily recitations in some one scientific study. This may be either astronomy, botany, chemistry, geology, physics, zoölogy, or physiological psychology. No knowledge of any science is required for admission. Each student must in addition select some one department in which he will pursue all the required work, 3 or 4 years being occupied in this way. The departments of botany and zoölogy are under separate management, full courses being offered in each. These courses are not necessarily taken at any fixed time, but with certain restrictions are grouped together at the will of the student.

The work in botany begins with a course of daily recitations and practical exercises in elementary botany through two terms. To students who have completed this there is open a course in cryptogamic botany lasting through two terms, and a course in the morphology and development of phanerogams in the third. When this is completed

students may follow a course in advanced cryptogamic botany, consisting of daily laboratory work with prescribed reading through one year. A further course is offered in vegetable histology, consisting of daily practical work in the study of minute anatomy of the vegetative organs of higher plants, with collateral reading. This occupies two terms, and may be followed by a course in vegetable physiology in the third.

The study of zoölogy begins with a course in general zoölogy. In this a number of selected animal types are dissected. This course includes daily exercises through two terms, and must be taken before the student will be admitted to any of the other courses. He may then take a course in comparative anatomy, consisting of daily exercises through one year, and a course in human and comparative histology occupying the same time. To students who have had some training in histological methods a course in embryology is open, attention being given principally to the development of the chick and the batrachians. A course is given in human and comparative physiology during one term, consisting of three lectures and laboratory exercises per week. There is further provided a course in systematic zoölogy, consisting of daily laboratory exercises in the identification of birds and fishes. Lecture courses are given, dealing with the history of zoölogy, the theory of evolution, and other theoretical questions; also upon the general morphology of the animal kingdom.

In all of the courses, in both botany and zoölogy, laboratory work is kept very prominent. The facilities for this work are very complete. A special building, Owen Hall, 71 by 65 feet, and containing two stories and a basement, is devoted to the biological laboratory and museum. The equipment of this building for work in general zoölogy and botany is all that could be desired. Most of the work done in this laboratory is in connection with the regular courses of instruction, but a considerable amount of original research is also made. Students who elect botany or zoölogy as a special study are required to devote a considerable portion of the senior year to the preparation of a thesis which shall embody the result of their own experiments or observations. These may be based upon the solution of some morphological or physiological problem; but are now frequently (in zoölogy) based upon the study of some special group of vertebrates.

The work of teaching as well as investigation is much facilitated by a valuable reference library kept easily accessible, containing many of the current journals and standard reference books, and a museum of considerable size. This collection consists of three divisions; one is arranged in the order of classification so as to present a synoptical outline of the animal and vegetable kingdoms by means of selected specimens. A second division illustrates as completely as possible the flora and fauna of the State, while a third contains material to be used in original investigations by professors and students. The museum contains about 6,000 specimens of insects, and about 3,000 specimens of

marine invertebrates. The vertebrates are illustrated by about 1,900 mounted specimens and skins of mammals and birds, and about 27,000 specimens of fishes.

IOWA COLLEGE.

GRINNELL, IOWA.

For admission to the freshman class elementary physiology is required. In the freshman class each student is required to take a course in free-hand drawing as a preparation for the sketching required in the laboratory work. A course in botany is also given during this year, largely physiological in nature.

The general biology course begins in the junior year and consists of laboratory work with occasional lectures. In this course many animal and vegetable forms are examined, and as far as practicable, students are required to collect their own specimens.

The headquarters of the department are in Blair Hall, a large building recently erected, and three rooms are devoted to it. One of these is fitted up as a storeroom and library; the second is used as a lecture room and laboratory, and connected with this is a smaller laboratory, the two rooms giving accommodations for about sixty students.

The equipment of these rooms consists of twelve microscopes and a number of camera lucidas, micrometers, etc. It is also provided with a complete outfit for microphotography.

IOWA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS.

AMES, IOWA.

Biological work begins in the freshman class, during the first half of which a course of lectures and field exercises in economic entomology is given. This course is intended to perform the double function of introducing the student to the study of living things, giving the necessary training in exact observations, etc., and giving him a practical knowledge of the life history of injurious insects and the means employed for combating them. Each student makes a collection of insects and prepares a descriptive paper based upon his own studies of some selected insect.

In the second half of the freshman year botany is taken up, the course running over through the first half of the sophomore year. The student at first becomes familiar with the general morphology of flowering plants by frequent exercises in drawing and making written descriptions of the forms studied. During the sophomore year the student is required to make a collection of seventy-five species of phænogams, and in addition one afternoon each week is spent in laboratory work in structural botany.

During the second half of the sophomore year cryptogamic botany is taken up. Special attention is given to parasitic fungi, notably those affecting cultivated crops, but all the types are treated from the lowest forms up to the vascular cryptogams. Special work on bacteria may be elected, this being mainly laboratory work devoted to the acquirement of the methods of cultivation and the study of the germs of various diseases.

Zoölogy is begun in the second half of the sophomore year, the course being largely laboratory work and dealing with the general morphology of animals. Typical forms from the leading classes are dissected. This work is continued into the junior year, attention being then given largely to systematic zoölogy and the classification of animals. In the second half of the junior year a course is given in comparative anatomy and physiology, including comparative embryology. In this the structures of the various organisms are described in detail for the adult forms, after which the evolution of the various systems are traced from their earliest beginnings to their most differentiated forms.

The foregoing comprise all the general courses required of all students.

Certain other courses may be elected and special courses may be required of students in special lines. A course in pharmaceutical botany is required of students in the veterinary course. This consists of a series of lectures and laboratory exercises on the principal medicinal plants. A special course is provided for engineering students, in which attention is given to the microscopic structure of various woods, also the fungi that are specially injurious in causing rot in railroad ties, bridge timbers, etc. Separate laboratories are provided for zoölogy and botany. Each possesses twenty-five microscopes of ordinary powers, and in addition numerous objectives of high powers. There is a good outfit of microtomes and all other appliances needed in undergraduate work. The museum is one of the best working collections to be found in the West. It is arranged primarily with reference to students' use. It contains many typical examples of all the principal groups of animals, its most striking feature being a very complete collection of the birds and insects of Iowa.

A new building is in course of erection for the department of zoölogy and entomology. This building will contain two large laboratory rooms, one for general the other for special work, a lecture room, several store-rooms, a room for rearing insects, and several rooms in which the museum is displayed.

In the arrangement of the laboratory, provisions are made for advanced as well as elementary work, and opportunities for original work in both botany and zoölogy are freely offered to all students qualified to undertake it. The facilities for advanced work in bacteriology are especially good.

JOHNS HOPKINS UNIVERSITY.

BALTIMORE, MD.

The prominent place which this institution holds among the colleges of the country, as well as the special attention there paid to biological teaching and research, give a special interest to the methods there employed and the facilities possessed.

Students applying for admission are required to present some one scientific subject for examination, an elementary knowledge only being required. To the undergraduate student several combinations of studies, all leading to the degree of bachelor of arts, are open. Biology is most prominent in a group arranged as a preliminary to medicine, and requiring ordinarily three years for its completion. Before taking up the study of biology the student is required to spend a year in the study of physics and chemistry, doing a considerable amount of practical work in each.

The work in biology begins with a course in general biology, which is preliminary to all the other courses. This consists of three lectures and 6 hours' laboratory work from the beginning of the session to the middle of April. "Attention is directed to the broad characteristic phenomena of life and living things, rather than to the minutiae of descriptive botany or zoölogy, or the character of orders, genera, and species. In the laboratory the student learns how to observe, how to verify and describe what he observes, how to dissect, and how to use a microscope; he examines selected vegetable and animal types from unicellular organisms, as the yeast plant and amœba to the fern and flowering plant on the one side and the crayfish and a mammal on the other. In the lecture room attention is mainly given to the fundamental biological facts and laws which the particular plant or animal under consideration is fitted to illustrate, the object being rather to give the student an idea of what is meant by the terms living thing, plant, animal, tissue differentiation, life history, organ, function, etc., than to teach him the elements of botany and comparative anatomy as commonly understood."

Running parallel with this and occupying 2 hours weekly is a series of lectures and exercises in human and comparative osteology. In this the human skeleton is carefully studied, and then one skeleton from each order of mammals, after which two or three skeletons are taken up from each of the main groups of vertebrates.

At the conclusion of the course in general biology the subject of embryology is taken up and continued to the end of the year. "In this course the student who has already in the general biology course observed the natural arrangement of animals and plants in diverging series, ranging from a simple bit of living matter to highly complicated organisms, studies the individual development of one of the higher ani-

mals from its start as an almost formless bit of living matter to its final highly complex structure. The increasing differentiation of tissues and organs which he has noted as higher and higher plants and animals were dissected, he now sees exemplified by the chick embryo in different stages of development. At the same time a good foundation is laid for subsequent advanced study in vertebrate morphology."

Beginning at the same time as the course in embryology, and occupying 2 hours weekly to the end of the year, is a course in systematic botany and plant analysis.

In the second year a course in mammalian anatomy is given. This consists of two weekly lectures with laboratory work lasting from the beginning of the year until Christmas. In this connection each student makes a thorough dissection of some mammal, working with all of the minuteness of the medical student upon the human subject.

A course in animal physiology and histology is given, consisting of three lectures and 6 hours' laboratory work weekly through the year. "This course is designed to give the student a good knowledge of the healthy properties and mode of working of the various tissues and organs of the higher animals, man included; also to give him a good knowledge of their microscopic structure. In the laboratory each student examines for himself the histology of each organ and tissue, and thus learns the use of reagents and imbedding materials, the methods of mounting specimens, etc.; he also studies practically the composition of the more important organs and tissues, the chemistry of digestion, the fundamental properties of living muscles and nerves, the beat of the heart, the phenomena of reflex action, etc. Important physiological facts which require special skill for their exhibition or the employment of especially delicate instruments, are demonstrated to the class. There will be as a rule one such demonstration weekly."

A course in the elements of zoölogy, consisting of two lectures weekly and related laboratory work, continues from Christmas to the end of the session. In this attention is paid to the structure, relationship, and classification of animals. This work may be continued by students desiring to do so at the marine laboratory, conducted by the university during the summer vacation.

The biological laboratory is a handsome building 84 by 52 feet, and having three stories and a basement. The first floor is devoted to class instruction, containing the lecture-room, storerooms, and a general laboratory for class use 32 by 48 feet area. This room is fitted up for class work in general biology, comparative anatomy, physiology, and physiological chemistry, and the arrangement of the room as regards light and general convenience is all that could be desired. On the second floor are two smaller laboratories for advanced work, one in botany, the other in animal morphology. On this floor are also the special library of the department, the museum and preparation rooms, and the photograph room.

The third floor is largely devoted to the uses of advanced workers in physiology and histology. Four work rooms are used in physiological investigation, one being adapted for general work, another having special appliances for the study of the circulation, a third being specially fitted for muscle physiology, and a fourth for physiological optics. On this floor is also situated a workshop provided with lathes and all necessary tools for working in metals.

In the basement are two rooms specially arranged, the one for physiological chemistry, and the other for electrophysiology. The basement also contains the animal storage room and the cremation room.

All of these rooms are unusually well suited for the work for which they were designed, and the equipment of each room is ample. The general undergraduate laboratory will comfortably accommodate fifty students, and the university possesses a sufficient number of microscopes for each student to have one assigned for his own use. Most of the smaller pieces of physiological apparatus are also provided in great abundance, so that a considerable number of students may be occupied with the same piece of work at the same time.

The equipment for advanced work in morphology and physiology is very complete. For the former the university possesses numerous objectives of high power, cameras, imbedding apparatus, automatic and sliding microtomes of the most approved designs. The apparatus for physiological investigation cost over \$10,000, and there is a yearly appropriation of \$1,500 for making additions to the stock. There are many large and costly pieces of apparatus devised for the study of special problems, notably, the physiology of muscle and nerve, and the physiology of the circulation. In addition there are numerous forms of recording apparatus and other appliances generally needed in physiological investigation. A mechanic is kept constantly employed in keeping this apparatus in repair and making any new pieces that may be needed either for class instruction or for research.

No large museum has ever been collected. The university has had no funds to spend in gathering together and maintaining a large collection. The policy has been to get together whatever materials were necessary for the work of teaching and for purposes of research to send her students to the homes of the animals to be investigated. The museum is accordingly a rather unique collection of skeletons, dissected preparations, and entire alcoholic specimens. It contains a considerable number of types of invertebrates, enough to give the student a good idea of most of the classes and orders. The local flora and fauna are quite fully represented by collections made by the naturalist's field club. There is also a collection of ferns and mosses of considerable size and value.

The biological library is one of the most important features in the work of investigation. It contains a large number of the standard reference books, complete sets of nearly all the leading journals, and it now receives over forty of the current biological journals in four languages.

In connection with this may be mentioned the "Journal Club," an association of instructors and advanced students, which meets weekly for the discussion of the more important articles in the current publications.

Two fellowships, yielding \$500 each, are open each year to graduate students in biology, and there is in addition the Bruce fellowship in biology, open only to those who have obtained the PH. D. degree, and giving facilities for special advanced research.

In this connection should be mentioned the "Studies from the Biological Laboratory," a journal issued at irregular intervals, which has now completed its fourth volume. The publication was begun in 1879 in order to secure publication in the United States for the results of researches carried on in the laboratory.

Mention should also be made of the Chesapeake Zoölogical Laboratory, which was established by the university in 1878, but after nine seasons of successful work is temporarily discontinued. This laboratory was located at different points along the southern coast from the Chesapeake Bay to the Bahamas. The attendance varied in the different years from 6 to 16 workers, and only those were received who were qualified to pursue original investigations. As a result a large number of papers have appeared based on researches there conducted, and greatly increasing our knowledge of the anatomy, embryology, life history, and systematic relationships of animals already known, as well as containing descriptions of many forms previously undiscovered.

KENTUCKY UNIVERSITY.

LEXINGTON, KY.

The biological work required of all students consists of a course in anatomy and physiology, in which daily recitations are held through the first half of the freshman year, and a course of daily recitations in zoölogy and botany continuing through the second term of the junior year.

No preparation in natural science is required further than a course in physical geography. In connection with the college work no facilities for laboratory work are provided, and none is required. There is a museum containing anatomical specimens as well as natural history collections. These are used in illustrating the courses given.

LAFAYETTE COLLEGE.

EASTON, PA.

The admission requirements for the freshman class of the classical course include only the ordinary English studies and languages. The scientific and engineering courses require an elementary knowledge of physics.

In the classical course biology is required only in the senior year, when the subjects botany and zoölogy are treated during one term. In

the scientific course the first preliminary training is derived from mineralogy, which is studied during one term of the freshman year. During the second and third terms of the sophomore year botany is taken up, followed in the first term of the junior year by zoölogy.

In these courses practical methods are made use of, and students receive instruction in the use of the microscope and other means of refined observation. The laboratory is located in Pardee Hall, where are also stored the collections made by the Natural History Society, which is an important auxiliary to the department. The herbarium is rich in North American plants, and contains nearly the entire flora of Pennsylvania.

LAKE FOREST UNIVERSITY.

LAKE FOREST, ILL.

Students applying for admission to the classical course are examined in elementary physiology, while those entering the scientific course are expected to have some knowledge of physical geography, physics, and botany. In connection with the latter, a written description of twenty-five species of phanerogams based on analyses made by the student must be submitted. The requirements for entrance to the scientific course will be greatly raised in the fall of 1891. They will then include requirements in physics, chemistry, zoölogy or geology, and botany, with laboratory work in each, also physiology.

The college work begins with a course in general biology in the first term of the freshman year, occupying 4 hours per week, followed in the second term by a course in the comparative anatomy and physiology of invertebrates, and in the third by a course in the structure and development of plants. In the second term of the sophomore year, 4 hours weekly are devoted to vertebrate zoölogy, and in the third term the same time is given to embryology. Throughout the junior and senior years biology is offered as an elective to all students, opportunities being given for work of a more advanced character. Laboratory work is required in connection with all these courses. In every course to which 3 schedule hours weekly are allowed, there are 4 hours of laboratory work and one recitation. In a 4-hour course there are 6 hours spent in the laboratory and one recitation, or 4 laboratory hours and two recitations at the pleasure of the instructor.

The biological laboratory is well equipped for purposes of class instruction, and has in addition separate rooms for research in the departments of histology and embryology. Each student is supplied with a microscope and the usual appliances. He is required to make drawings and written descriptions of the forms studied. Attention is first given to unicellular animals and plants, after which a practical study of the structure and functions of higher plants and animals is made on a series of typical forms.

LAWRENCE UNIVERSITY.

APPLETON, WIS.

The examination for admission to the freshman class includes the subjects of physiology and physics, only an elementary knowledge of each being required, and that being furnished by the preparatory department.

In the scientific course zoölogy is taken up, 5 hours weekly being devoted to it during one term of the freshman year. This course is elective to classical students. During the third term a course in botany is given, occupying 5 hours weekly. This is required of scientific freshmen, but may be elected by other students. Both of these courses are largely practical, animal types being studied in connection with the former course, while in the latter each student is required to collect and analyze 100 wild plants and present them properly mounted and labeled.

A course in general biology, consisting of two exercises weekly, is elective to seniors in all courses. In this all the time is devoted to the practical laboratory study of typical animal and vegetable forms.

LENOX COLLEGE.

HOPKINTON, IOWA.

In the preparatory department a course in physiology is given, continuing through one term. In the classical course zoölogy occupies the third term of the junior year, and no other biological work is done. In the scientific course botany is begun in the spring term of the freshman year and continued through the first term of the year following. In this course a general study is first made of vegetable morphology and physiology, and the classes of cryptogams are then taken up. In addition to the class work, each student is required to prepare a herbarium containing 50 flowering plants, of which he must submit a written description. In the third term of the sophomore year a course is given in zoölogy, in which attention is directed mainly to the study of comparative physiology.

There is no laboratory, and the only means of illustrating the biological courses are found in a natural history collection consisting principally of shells and corals.

LOMBARD UNIVERSITY.

GALESBURGH, ILL.

Candidates for admission to the scientific course must possess an elementary knowledge of physiology, zoölogy, and botany. Of classical students no knowledge of science is exacted. In the scientific course the introduction to scientific studies is furnished by an elementary course in chemistry in the freshman year, followed in the sophomore year by

courses in physiology, zoölogy, and botany, one term being devoted to each. This work is required of both classical and scientific students.

The work in physiology consists of daily lectures, recitations, and demonstrations, with which is associated practice in dissecting. Hygiene receives considerable attention in this connection, the aim being to make the course practical as well as disciplinary. The work in zoölogy consists of lectures and demonstrations, with dissection of typical animal forms. In addition to daily recitations in botany in the third term, each student is required to make a small herbarium.

The work of teaching is facilitated by a museum consisting of a miscellaneous collection of zoölogical specimens, in which birds and corals are especially abundant. There is no laboratory biological work, and no provision has been made for any courses more advanced than those above mentioned.

LOUISIANA STATE UNIVERSITY.

BATON ROUGE, LA.

Three undergraduate courses of study are here provided. In the agricultural and mechanical courses students study biology during 2 years, beginning with the sophomore. In the literary course biology is begun in the junior year, but the course pursued is identical with that pursued by sophomores in the other courses. Literary students begin the study of biology with some preparation in chemistry; other students have in biology their introduction to scientific work.

The work of the sophomore class (pursued also by literary juniors) consists of five recitations weekly in zoölogy during the first term, and a like number in botany during the second. In the junior class 2 hours weekly are devoted to zoölogy during the first term, and 3 hours to botany during the second. In the sophomore class the work is first general zoölogy, but, special attention is given to the anatomy and physiology of domestic animals, because of its important bearing upon agriculture. The work of the second term is a study of vegetable morphology and physiology. In connection with this, each student is required to analyze and preserve one hundred plants, making full records of their characters. In the junior class attention is given to the anatomy, physiology, and life history of insects with especial reference to forms most injurious to agriculture. Each student is required to collect, mount, and dissect a sufficient number of insects to gain a general acquaintance with the leading characters of the group. The botanical work of the second half-year is a special study of forage plants, with practical work in the analysis of grasses. A short course is also given in cryptogamic botany, paying special attention to parasitic fungi. Some practice in the microscopic examination and identification of these is required of each student.

There is no laboratory equipped for biological work, and the only aids in the practical work of teaching are the botanical garden and the museum. The former is being rapidly equipped, and furnishes all mate-

rial necessary to illustrate the course in botany. The herbarium consists of three separate collections, one containing about 3,000 specimens, another about 12,000, and the third, which was made by the authority of the legislature, containing about two-thirds of the flora of the State. There is a large collection of zoölogical specimens, but no adequate provision being made for storing them, they are of little value in aiding the work of teaching.

Most of the students enter the sub-freshman class. For admission to this a knowledge of merely the ordinary English studies is required. Students applying for admission to the college course must pass an examination upon the work of the sub-freshman year, the scientific work in this consisting of a course in physiology and hygiene, continuing through one term. Much complaint is made of the inadequate preparation afforded by the schools of the State.

MAINE STATE COLLEGE.

ORONO, ME.

The examinations for entrance are limited to the ordinary English studies and mathematics, and no scientific branches are required.

The course of study upon which special emphasis is laid, and for which the college is specially designed, is the course in agriculture, but in addition to this there are courses in engineering and several courses leading to the degree of bachelor of sciences. In all the courses physiology and botany are required in the freshman year, half the year being devoted to each. These subjects are practically taught, and in connection with each, 4 hours weekly are devoted to laboratory work. During the sophomore year there is an advance in the agricultural course. Attention is devoted to cryptogamic botany, and an important part of this work is the laboratory study, which occupies 10 hours weekly. In the second term of the junior year zoölogy and entomology are taken up. In the first named, lectures are delivered upon the principal groups of the animal kingdom, and students are required to make critical studies of the typical members of each group. The course in entomology consists of a general review of the orders of insects, illustrated by many of the more common forms. Following this, the injurious and beneficial insects are taken up more in detail, their life histories described, and the methods of treatment adapted to special cases pointed out. To furnish practical illustrations of this course many of the injurious insects are bred and carried through all their transformations in the class room, thus giving every student an opportunity to observe the various changes and recognize the different stages; in short, to acquire that practical knowledge of insect life which every well-informed agriculturist should possess. The subject of bee-keeping is also taken up and treated with considerable fullness, attention being paid to the methods of managing swarms and collecting products. During the senior year the subject of com-

parative anatomy is considered, under which head the anatomy and physiology of domestic animals are treated, followed by an outline of the common wild animals, and at the conclusion of this study instruction is given in stock breeding and veterinary science.

The headquarters of the department are in Coburn Hall, a building recently erected and admirably suited for the purpose. The museum which is there placed contains representatives of the leading groups of the animal kingdom, being especially rich in insects and marine fauna. In addition there are numerous models, skeletons, charts, etc. Among the botanical collections may be mentioned a herbarium containing about 900 species of the Maine flora, the Blake herbarium containing about 14,000 specimens of foreign and indigenous plants, both phænogams and cryptogams; the Ellis collection of North American fungi, consisting of 2,300 species; a collection of several hundred specimens of marine algæ, as well as other smaller collections.

THE MARINE BIOLOGICAL LABORATORY.

WOODS HOLL, MASS.

This occupies a unique position among the educational institutions of the country. It is devoted to biological work alone, and its location has been chosen with reference to the abundance of both animal and vegetable forms within easy reach. The session occupies the three summer months only.

Provision is made for two classes of workers: investigators and students. For the former there are provided fourteen private laboratories and one general laboratory. To these no instruction is given, but all the resources of the laboratory are freely open. Every year a certain number are invited to carry on their researches here free of all cost. For those who are not prepared for original work special courses of instruction are provided. Lectures are given upon general subjects in zoölogy and botany, and laboratory work accompanies each. In addition to this, short lecture courses are devoted to special groups of animals or plants, the details of these varying from year to year. The laboratory for students accommodates about thirty workers, preference being given to teachers and others not beginners.

The laboratory consists of a two-story building 63 by 28 feet. Although it has been occupied but three seasons it is already much too small to accommodate those seeking admission. The equipment has been provided with great thoroughness with special reference to the needs of investigators. The laboratory possesses abundant facilities for collecting marine forms, and salt-water aquaria are also provided in abundance. Of special value to investigators, also, is the library, which contains complete sets of many of the standard journals, in addition to other publications.

MARYLAND AGRICULTURAL COLLEGE.

AGRICULTURAL COLLEGE P. O., MD.

The biological course which all students are required to follow continues through four years. The first part of the freshman year is taken up with a consideration of the environment of living things, after which the classification of plants is taken up. Each student is required to familiarize himself with the names of the common trees and other plants of the vicinity of the college, also to prepare a small herbarium. In the sophomore class the domestic and wild animals are studied in the same way. While engaged in this work the student spends 4 hours weekly in recitation, and has in addition one field exercise.

The junior class study the morphology of selected animal and vegetable forms, principally those that are popularly well known, and the seniors devote their time to the physiology of these same forms, leading up to human physiology. This course consists of three lectures and 3 hours laboratory work weekly, with occasional field work.

The laboratory possesses no striking peculiarities of construction, and is equipped with a moderate outfit of microscopes, dissecting instruments, etc. The museum contains a small number of preserved animal specimens and a few skeletons. There is also a herbarium, illustrating the entire flora of Maryland and the District of Columbia, and a collection of about 400 varieties of woods grown in the United States.

MASSACHUSETTS AGRICULTURAL COLLEGE.

AMHERST, MASS.

No scientific subjects are included in the requirements for admission to the freshman class.

During the entire four years of the course the student is engaged in biological work. This begins with botany in the freshman year, in which structural botany is taken up in the first term and analytical botany in the third, 5 hours being given to each. Economic botany follows in the first term of the sophomore year, laboratory work being continued over into the second term, with horticulture in the third. Anatomy and physiology are also studied during the second term for 5 hours weekly. Zoölogy is begun in the junior year, 8 hours weekly being devoted to laboratory work during the first term, and 3 hours to lectures during the second. Entomology receives 7 hours weekly during the third term. In the senior year the comparative anatomy of domestic animals is studied for 5 hours weekly during the first term, while veterinary science occupies 4 hours during the second.

This institution possesses ample facilities for the work done, and laboratory work is prominent throughout the course. Separate working rooms are provided for botany and zoölogy, and each has its own equipment of microscopes and other necessary apparatus. Ample

greenhouse space is also provided for experiments in vegetable physiology.

The zoölogical collection includes a series representing the animals of Massachusetts, together with a considerable number of skeletons, models, and stuffed animals. The botanical collection consists of a herbarium of more than 10,000 specimens from all parts of the world, and contains besides a large number of specimens of woods, models of fruits, abnormal growths of stems, etc.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY.

BOSTON, MASS.

This institution offers eleven courses of instruction, each leading to the degree of bachelor of science. For all these courses the work of the first year is the same, consisting of mathematics, languages, etc., the only scientific work being chemistry with laboratory work required. Students who elect the course in biology, begin their work with a course in general biology, to which 6 hours weekly, with additional time for laboratory work, are devoted. This course begins with a review of the differences between living and dead matter, and after a consideration of such subjects as organs, tissues, cells, protoplasm, etc., a thorough examination is made of selected animal and vegetable types. These are chosen from among the higher forms. In the second term a course in biology of the microörganisms succeeds that of general biology. This begins with a study both by lectures and laboratory work of the smallest living things. During this year there is also presented a course in zoölogy occupying 2 hours weekly, with additional time spent in the laboratory. In connection with this there are frequent excursions and opportunities for practical seaside work.

In the third year a course in cryptogamic botany during the first half-year forms the natural sequence to the general biology course. During this same period there is given a course in anthropology, and a course in comparative anatomy, followed in the second half-year by a course in comparative embryology. In connection with these courses there is abundant time for laboratory work, in which the student acquires skill in dissecting as well as practice in the use of histological methods. In the fourth year, students in the biological course are allowed to specialize to some extent, courses being offered in comparative physiology, advanced zoölogy, and sanitary biology. For the special benefit of such students a reading club is organized for the purpose of keeping abreast with the current biological literature.

In the course of "general studies," answering nearly to the scientific course usually given in colleges, biology enters in the second year, the work being general biology and zoölogy in the first term, and zoölogy in the second term of the second year. These courses are identical with those above given.

In the sanitary engineering course students pursue the courses in general biology and the biology of the microorganisms, already described, with work in sanitary biology in the fourth year. Laboratory arrangements are made for students doing routine work in connection with the lecture courses, and also for those engaged in research. Microscopes have been provided in sufficient number for each student to have one for his own exclusive use, and the usual accessories are provided in abundance. The laboratory also possesses appliances for research in physiological chemistry; microtomes of various makes and other appliances for histological research; culture and sterilizing ovens and high-power microscopes for work in bacteriology; and kymographs, moist chambers, and the smaller apparatus needed in the study of muscle and nerve physiology.

No requirements in science are made of students applying for admission to the first-year course. An elementary knowledge of physics is recommended but not prescribed. It will be noticed that the scientific work of the college begins with an experimental science—chemistry—and that the subsequent scientific work rests upon that as a foundation.

MIAMI UNIVERSITY.

OXFORD, OHIO.

For entrance to the freshman class no science is required. The scientific work of the college begins with a course in physics, which is required in the sophomore year. This is fully illustrated but does not include laboratory work. All the other scientific courses are elective in the junior and senior years. The biological work begins in the junior year with a course in general biology, occupying 3 hours weekly through one term. Most of the time is spent in laboratory work upon a series of animal and vegetable types, occasional lectures and demonstrations being given. In the second term, a course is given in comparative anatomy and physiology, followed in the third by work in botany. In this the student gains a practical knowledge of the structure, development, and classification of plants, and gets some acquaintance with vegetable physiology and histology.

In the senior year human anatomy and physiology are studied 3 hours weekly during the first term, the course being designed to give the student a general idea of the uses of the various parts of the body and their mode of action in health. In connection with this a course is offered in comparative histology and osteology, in which special attention is given to laboratory work, including the methods of preparing tissues for microscopic study. During the last term of the senior year a course in embryology is given to illustrate the manner of vertebrate development, and to serve also as an introduction to the methods of research employed in embryology.

Students intending to take the work of the senior year are urged to take the course in chemistry offered in the junior as a preliminary thereto.

The laboratory equipment consists of microscopes, microtomes, dissecting instruments, etc., in limited number. The facilities will soon be greatly increased.

MICHIGAN AGRICULTURAL COLLEGE.

LANSING, MICH.

Biological work begins in the third term of the freshman year. A course in botany is then given, consisting of daily exercises in the morphology of flowering plants. The special aim of this course is the acquirement of accuracy in observations; hence, at first most of the time is devoted to practical work. Each student does some work with the microscope, and is required to write a thesis embodying the result of his own work. This work is continued during two terms of the sophomore year, special attention being given to the analysis of flowering plants, including the more difficult families. Physiological botany is studied also during the sophomore year, the course consisting mainly of laboratory work.

During half the first term of the junior year a course is given in comparative anatomy, followed in the second term by a course in physiology. In these courses the lectures are abundantly illustrated by models, preparations, etc., and in addition each student is required to spend sufficient time in dissecting to acquire a general familiarity with the position, appearance, and relations of the various organs in the animal body, in a state of health, and the changes produced by disease. This course consists of daily lectures, 30 hours being devoted to laboratory work. In the third term of the junior year a course is given in entomology, consisting of daily lectures and 3 hours weekly laboratory work.

The course includes the anatomy, transformations, and distribution of insects, with special reference to the forms injurious to vegetation, and the methods for combating them. Students are required to collect, rear, and preserve specimens of native insects, also to carefully examine and dissect a sufficient number to become familiar with the methods of determining the families and genera of insects.

In the senior year a course in general zoölogy is given, consisting of daily lectures and 5 hours' laboratory work weekly during 6 weeks. This is mainly descriptive zoölogy, attention being paid to the habits and distribution of animals, but especially to the principles of classification. Each student is required to make a special study of one class of animals, determining the species from his own study of the animals themselves.

During the third term of the senior year elective courses in botany are offered. One of these is a course in cryptogamic botany, consisting

mainly of laboratory work on the lower plants, with occasional lectures. Instead of this, students may elect a special course devoted to grasses and clovers, or a course in forestry.

Special laboratories are devoted to zoölogy and botany. There are several working rooms in each and the equipment is ample for the work there performed. The museums and herbarium are of special value. The latter contains over 4,000 species of European plants from the Kew gardens, and about 2,000 native species additional. There are besides 2,300 species of fungi and 650 species of grasses, and other smaller collections recently added. The botanical museum contains "collections of timber and timber products, illustrating the numerous ways in which trees are injured, many articles manufactured from wood and other vegetable substances, also grasses, grains, fruits, seeds, gums, resins, dyes, fungi, mosses, lichens, etc. The general museum contains the leading representatives of the fauna of the State, the collections of insects being especially noteworthy. There are besides collections of marine invertebrates and numerous skeletons and alcoholic preparations of animal tissues and organs.

As further aids in the work of teaching, should be mentioned the apiary, fitted with the most approved apparatus; a large greenhouse, containing a large number of choice ornamental plants; a botanical garden, containing nearly 1,000 species of native and foreign plants, and an arboretum and sample grounds for timber trees.

The aim throughout is to make the courses very practical and illustrate them as fully as possible. No scientific knowledge is expected of students applying for entrance. Scientific work is begun in the college in order to insure correct methods at the start.

MILLS COLLEGE.

MILLS COLLEGE, CAL.

The course in general biology is limited to the last term of the senior year, 2 hours weekly being devoted to it. Most of this time is given to class work with a text-book. In connection with this, specimens are examined. Attention is mainly given to higher representative plants and animals, and all students are required to follow the practical work. The subjects of botany and zoölogy are introduced in the lower classes, giving some preparation for the senior year.

There is no laboratory at present, but it is expected that a new building will soon be erected, affording all needed accommodations.

MILTON COLLEGE.

MILTON, WIS.

Biology begins in the sophomore year with a course in physiology, consisting of daily recitations through the third term. Zoölogy is then taken up during the first term of the junior year, followed by botany in

the third. Daily recitations are conducted in all these courses, and about one-third of the entire time is devoted to practical work. No special room for laboratory purposes is provided, this work being done in the class room. A small number of microscopes are provided, as well as dissecting instruments and other appliances. As an aid in the teaching of botany there is a herbarium, consisting of more than 1,800 species of flowering plants.

No requirements in science are made of students applying for admission to the freshman class.

MONMOUTH COLLEGE.

MONMOUTH, ILL.

The only biological subjects taught are botany and physiology, which occur in the freshman and senior years, respectively, and each occupying five recitations weekly during three months.

No laboratory is provided, and no practical work is required except the examination and determination of a small number of flowering plants in connection with the course in botany.

No requirements in science are made of students applying for admission to the freshman class.

MOORE'S HILL COLLEGE.

MOORE'S HILL, IND.

In the junior year of the preparatory course elementary instruction is given in physiology, followed in the senior year by courses in elementary chemistry and physics. For admission to the college course this amount of science is required. In both the classical and scientific courses the same requirements in biology are made.

Botany is taken up in the third term of the freshman year, preceded in the first and second terms by chemistry, including laboratory work. The work in botany consists of a study of the morphology of flowering plants, together with practice in plant analysis. In the third term of the sophomore year a course in physiology is given, followed in the first term of the junior year by a course in general biology. This consists mainly of a series of practical laboratory exercises, attention being given first to the lower forms of animal and vegetable life, proceeding thence to the more specialized. In connection with this, instruction is given in the methods of histological work. During the senior year elective courses in structural botany and zoölogy are offered.

The laboratory equipment consists of six compound microscopes and other apparatus necessary. The quantity of apparatus is not sufficient, but the attempt is made to give as practical a character as possible to the work. The laboratory is conveniently arranged for elementary work, and all students are required to spend 8 to 10 hours weekly during six months in laboratory work.

MOUNT HOLYOKE SEMINARY AND COLLEGE.

SOUTH HADLEY, MASS.

Students applying for admission are expected to have an elementary knowledge of physiology and botany. Two collegiate courses are offered in which the requirements in biology are nearly the same, and a third course, known as the "seminary course," is also provided. In all three of these courses the introduction to scientific work is furnished by chemistry, the course consisting of lectures and laboratory work through the third term of the first year. In addition there are in the "seminary course" a series of lectures and laboratory exercises in botany, including vegetable histology and cryptogamic botany, and also a course of lectures in physiology through half the year. This latter course is also required of scientific students during their first year.

During the second year students in both the scientific and classical courses follow the same course in vegetable morphology and histology as above mentioned in connection with the seminary course. In the second year of the seminary course there are in the first term 6-weeks' courses in botany and zoölogy, and in the third term a further course in zoölogy, in which special attention is paid to laboratory work on the vertebrates and to the principles of classification. A course in zoölogy identical with this is required of classical and scientific students in the first term of the third year, together with a laboratory course in botany. No further work is prescribed, but biology may be elected through the entire course. The work is everywhere made as practical as possible, the necessity of laboratory work being strongly insisted on. In connection with the second year's work the analysis of 175 plants is required, of which 75 must be preserved in an herbarium. These must include the more difficult orders of phænogams, as well as a number of cryptogamic forms.

The work in zoölogy begins with a study of the classification of the animal kingdom, illustrations being obtained by an examination of the external forms of the vertebrates. One or more vertebrate forms are dissected, after which attention is given to invertebrates, which are similarly studied. The work in physiology in the first year is of an elementary character, but the subsequent elective courses are supplemented by laboratory work in the dissection of animals and physiological experiments proper.

The biological work of the junior and senior years is more general in its character, consisting mainly of laboratory work in physiology, histology, and embryology. Lectures are also occasionally given on the fundamental principles of biology.

The biological department is situated in a recently-constructed building, which furnishes all desired conveniences. Two laboratories are provided for zoölogy and one for physiology. In the same building is a room containing aquaria and other conveniences for the study of live

plants and animals. A small botanical garden facilitates the work in that department, furnishing materials for the study of vegetable physiology as well as for plant analysis. The equipment of the laboratory consists of thirty-six dissecting microscopes, twenty-five compound microscopes, and microtomes and smaller apparatus in abundance.

MOUNT UNION COLLEGE.

ALLIANCE, OHIO.

The biological work begins in the freshman year of the college course, with human physiology. Four hours weekly are given to text-book recitations and one to lectures and demonstrations. Zoölogy is then taken up, the same amount of time being given to it as to physiology. As an aid in presenting this subject the college possesses a museum of considerable size, and each student following the course is required to spend 1 hour weekly in museum work. A course in botany is also offered, in which 4 hours weekly are devoted to class work and 1 to plant analysis. This course is facilitated by a herbarium, but much of the material is collected by students themselves, as is the case also in the zoölogical course.

The laboratory has the ordinary equipment, and contains accommodations for about thirty students.

No requirements in science are made for admission to the freshman class.

MUHLENBERG COLLEGE.

ALLENTOWN, PA.

Biological work begins in the freshman year, which is equally divided between physiology and zoölogy, there being one weekly exercise through the year. In the sophomore year a course in botany is given, occupying 2 hours weekly during half the year.

These subjects are taught by means of text-books, and illustrated by charts and objects. There is no laboratory, and no practical work of any kind is required of students. No preparation in science is required for entrance.

NORTHWESTERN UNIVERSITY.

EVANSTON, ILL.

For admission to the freshman class in the classical or philosophical courses the candidate must possess some knowledge of physics and physiology. In the scientific department zoölogy and botany are required in addition. This preliminary instruction is given in the preparatory department, one-third of a year being required in each of these branches except physics, to which one year is given. Most of the high schools of the State also furnish the requisite scientific preparation.

The work in biology begins in the college course with the sophomore year, a course in comparative zoölogy being prescribed in the first and second terms. In this, one lecture is given weekly on the structure and functions of animals. Scientific students may elect in the second term a course in structural botany, spending 8 hours weekly in the practical study of vegetable tissues. Students in the literary courses may elect morphological and systematic botany in the third term, spending 5 hours weekly in lectures and laboratory work. A course in human anatomy, consisting of 6 hours laboratory work weekly, is required of scientific students in the third term of the freshman year.

Biology is elective in the junior year to all except scientific students. A course in zoölogy is given during one term, consisting of four weekly recitations but no laboratory work. A course in general biology runs through the entire senior year, and is elective to all students. This consists of three weekly lectures and laboratory work. In connection with this course a number of typical animals and plants are examined, beginning with higher animals and proceeding to the lower forms, after which the vegetable kingdom is taken up in the reverse order.

A special course, occupying two years, is provided for students expecting to study medicine. In this course systematic zoölogy and structural botany are required in the second term of the first year, 4 hours being given to each, and histology is studied 5 hours weekly in the third term. In the second year general biology occupies the first term, bacteriology the second, and physiology and embryology the third, 3 hours weekly being given to each.

The laboratory consists of one large room provided with sixteen microscopes and other apparatus needed in elementary work. No provisions have yet been made for advanced research, but something will be done in this direction in the near future, the available room being greatly increased and new facilities provided.

The museum is of great value in connection with the work of teaching. It contains about 15,000 botanical specimens from all parts of the world. Specially worthy of note is the collection of mosses, numbering more than 200 specimens. The zoölogical collection numbers about 20,000 specimens, in which are represented all the classes of animals, from the lowest marine forms up to and including the highest mammals.

OBERLIN COLLEGE.

OBERLIN, OHIO.

Candidates for admission are expected to have an elementary knowledge of physiology and physics, such as may be obtained at most of the high schools in the State, students being admitted from many of these on certificates.

Three different courses are offered, the biological work being nearly the same in all. Botany is begun in the third term of the sophomore year, preceded by physics and chemistry. In connection with this

the study of flowering plants is first taken up, each student being required to make a herbarium containing representatives of the more difficult orders as well as the more common ones. Vegetable histology is also taken up, the student being given abundant opportunity to learn the methods of microscopic work, and the preparation of sections from vegetable tissues. This course all students are required to attend, but the laboratory work is elective. The course in zoölogy, which occupies one term of the junior year, consists of comparative and systematic zoölogy. Lectures are given upon animal structure and development, and abundantly illustrated by specimens. The laboratory work follows the same general outline, consisting of the dissection and microscopic examination of selected forms, to represent the entire animal kingdom. The college possesses a valuable museum, illustrating the departments of zoölogy and botany. The local flora and fauna are very fully represented, and so arranged as to greatly facilitate the work of the class room.

The laboratory has been recently equipped with microscopes, microtomes, and other necessary apparatus for the study of animal and vegetable histology. At present laboratory work is not required, but may be elected by students following any of the biological courses.

OHIO STATE UNIVERSITY.

COLUMBUS, OHIO.

Students are admitted to the college classes when they complete the work prescribed in the preparatory department. In this the scientific work consists of courses in botany and physics with practical work in connection with each. Many of the high schools of the State furnish a sufficient preparatory course in science, and students coming from these are admitted on certificate.

Ten different courses are offered leading to different degrees. In five of these biology is prescribed, the requirements being different in the different courses. In the courses in arts, science, and philosophy, the scientific subjects are almost all elective, though some one involving laboratory work must be taken. Botany, comparative anatomy, or physiology may be elected in the sophomore year, 2 to 3 hours per week being given to these subjects. The course in botany is a continuation of the work of the preparatory department, and in it special attention is given to vegetable physiology and histology and economic botany, some attention being paid to special groups of plants important from an agricultural standpoint. Cryptogamic botany is also taken up with special reference to fungi injurious to cultivated plants. The course in comparative anatomy is based upon the study of typical vertebrates, after which other lower forms are dissected. The work in physiology which is required of students in the science course consists of recitations and laboratory work in general physiology.

In the junior year a course in general zoölogy, consisting of 5 hours laboratory work per week, may be elected, while courses are also offered in botany and physiology. The course in zoölogy consists in the dissection of a considerable number of typical forms, supplemented by lectures upon the classification of animals and other subjects not adapted for practical study. The botanical work is a continuation of that of the sophomore year, while the course in physiology consists entirely of laboratory work for 6 hours weekly through the year. This time is devoted to practice in the use of physiological apparatus, vertebrate dissection, and physiological chemistry.

The more extensive work in biology is in connection with the course in agriculture, attention being given to some branch of biology during the entire 4 years of the course. The anatomy of domestic animals and the general question of stock-breeding are considered in courses, to each of which 5 hours weekly are devoted during one term of the freshman year. Horticulture also receives attention during one term. Botany is required in the sophomore year, the course being much the same as in the junior year of the arts course. Zoölogy is likewise required in the junior year, the course consisting of lectures and laboratory work occupying 3 hours weekly.

The necessity of having a large amount of practical work done by students themselves is thoroughly appreciated, as is shown by the fact that the university possesses, in all, nine laboratories. Of these, one is used for botanical work and another for general work in animal physiology and dissection. These are both well supplied with the apparatus needed in class instruction and contain in addition some facilities for advanced research. The time required for laboratory work varies in the different courses between 4 and 6 hours per week. A considerable number of students are usually engaged in research, mainly upon questions in histology and the life histories of insects.

OHIO UNIVERSITY.

ATHENS, OHIO.

This institution provides three different courses of study, in which the amount of biology considered is the same, while the entrance requirements are somewhat different. These differences are provided for in the arrangement of the preparatory courses, physics being required as preliminary to the philosophical course in the second year, while in the pedagogical course physiology and botany occupy one term each of the third preparatory year. The same amount of instruction is offered by many of the high schools of the State.

Physiology is taken up in the sophomore year with two exercises weekly during two terms, followed by botany in the third term, in which there are five exercises each week, these two courses constituting the only work required in biology. The botanical course in the

preparatory department is a systematic study of flowering plants, while in the sophomore year attention is given to structural and physiological botany. The work in physiology is of a general character, attention being given first to gross dissection of lower animals, proceeding thence to the microscopic structure of the various tissues and organs. The work is made as practical as possible, and while there is no special laboratory the university possesses a stock of microscopes and physiological apparatus which are at present used in temporary quarters. Frequent excursions are made into the surrounding country for the purpose of studying the local flora and fauna.

OLIVET COLLEGE.

OLIVET, MICH.

In the three courses offered, viz, classical, literary, and scientific, biology is the first science studied, attention being given to phanogamic botany in the third term of the freshman year. No preliminary scientific training is necessary for admission to these courses, although for entrance to the scientific department physiology and physics are required as taught in the preparatory department of the college. The botanical work consists mainly in the dissection and classification of common plants, with some work in vegetable physiology.

Zoölogy (elective) occupies two terms of the sophomore year in the scientific and literary courses. The first term is devoted to a general survey of the entire field with reference to numerous specimens. The second is a laboratory course designed especially for teachers and prospective medical students. In this course many typical forms are dissected, and the methods of histological technique are taught.

In the junior year of the classical and literary courses physiology and anatomy are elective in the winter term. These courses are arranged to meet the legal requirements made of teachers. They are to some extent practical, being illustrated by charts, models, dissections, etc.

As aids in the work of teaching the college possesses a laboratory with a sufficient equipment of microscopes and accessories; also a synoptic collection of plants and animals well arranged for use. Opportunities are given for advanced work to all students who are prepared for it, and the provisions for such work are ample.

The requirements in science for entrance to the scientific course are met in the preparatory department, as well as in most of the high schools of the State, many of which send students to be admitted without examination.

OTTERBEIN UNIVERSITY.

WESTERVILLE, OHIO.

Botany is taught during the freshman year, followed by zoölogy in the sophomore. The time is devoted mainly to lectures and recitations, with a small amount used for practical work. This latter is

elective, and not a prescribed part of the course. No laboratory is provided. For admission to the freshman class an elementary knowledge of physics or astronomy, with physical geography, is required.

PARSONS COLLEGE.

FAIRFIELD, IOWA.

All students applying for admission to the freshman class are expected to have an elementary knowledge of physiology. In addition to this, scientific students are examined in physics, zoölogy, and botany.

In both the classical and scientific courses the work done in biology is the same, although during part of the junior year certain studies are required in the scientific course but elective in the classical. During the last term of the freshman year and the first term of the sophomore, in both courses, botany is taken up, the time devoted to it being 3 or 4 hours weekly, the remainder of the sophomore year being devoted to chemistry. Biology is taken up during the first term of the junior year, there being four weekly exercises, while during the second and third terms a course in zoölogy is open to classical students, but required of those in the scientific department. In the first term of the senior year a course of four lectures weekly in physiology is required of all students, and during the entire year students of both courses may elect a course of laboratory work in any special line.

In all the natural history studies laboratory work enters prominently, the main object sought being accurate observation, systematic investigation, and practical knowledge. For conducting this work microscopes are supplied, and for illustrating the course of the senior class the college possesses numerous charts and a human skeleton.

PENNSYLVANIA STATE COLLEGE.

STATE COLLEGE, PA.

This institution offers two general science courses and one general course in agriculture. Special courses are also given in natural history and advanced agriculture. The biological work of other courses is selected from the work prescribed for these.

An elementary knowledge of physics is required of applicants for admission to all of these courses except the general course in agriculture. In each of these courses the biological work consists of botany, zoölogy, and physiology in varying proportions, as shown below. The distinctive work of the special courses begins in the junior year.

The work in botany consists of text-book recitations and laboratory work. At first special attention is paid to structural and physiological botany, and many drawings are required. Constant practice is also given in the details of section cutting, mounting, etc. Systematic botany follows, and cryptogamic botany, with special reference to injurious

fungi, is then taken up. The course in zoölogy includes the actual microscopic study, and dissection of a series of types from the lowest animal forms to the vertebrates. Human physiology is studied by means of a text-book, but during a part of the course there is abundant laboratory work, special points, mainly anatomical, being made the subject of this study. A course of lectures on entomology is also given, in which the structure and systematic relations of insects are described, together with the economic considerations which arise from a study of the beneficial and injurious species. The collection and identification of insects is a part of this course.

The varying character of the biological work of the different courses may be seen from the following tabular view:

GENERAL SCIENCE AND LATIN SCIENTIFIC COURSES.

Course.	Class.	Hours weekly.
Physiology	Third-term freshman	3
Laboratory work	Second half-term	4
Botany	Third-term sophomore	5
Laboratory work	do	4
Botany	First-term junior	4
Laboratory work	do	6
Zoölogy	Second-term junior	4
Laboratory work	Third-term junior	2

GENERAL COURSE IN AGRICULTURE.

Physiology	First-term freshman	4
Zoölogy	Second-term freshman	5
Botany	Third-term freshman	5
Do	Third-term sophomore	5
Laboratory work	do	4
Botany (laboratory work)	First-term junior	6
Zoölogy	Second-term junior	4
Laboratory work	do	6
Zoölogy	Third-term junior	2
Comparative anatomy of domestic animals	First-term senior	4
Laboratory work	do	2
Botany	do	4
Entomology	Third-term senior	4
Laboratory work	do	6

COURSE IN NATURAL HISTORY.

[The work of the freshman and sophomore years is the same as that in the general science course.]

Cryptogamic botany	First-term junior	4
Laboratory work	do	6
Physiology	do	4
Zoölogy	Second-term junior	4
Laboratory work	do	6
Phænogamic botany	do	3
Entomology	Third-term junior	2
Laboratory Work	do	6
Zoölogy	do	2
Comparative anatomy of domestic animals	First-term senior	4
Zoölogy	do	5
Laboratory work	do	6
Embryology	Second-term senior	4
Laboratory work	do	8
Forestry	Third-term senior	3

The biological work of the advanced course in agriculture corresponds nearly with that of the course in natural history.

The botanical laboratory is especially well fitted for work, while the greenhouses furnish additional laboratory room for work in vegetable physiology. An outfit of microscopes and materials for the study of animals is also provided. The collections include a herbarium of more than 3,000 species, large collections of woods, numerous alcoholic specimens of animals, a collection of insects, a considerable number of skeletons, etc.

[The administration of the zoölogical department having recently changed hands, it is probable that the arrangement of courses in this department will be altered in September, 1891.]

RANDOLPH MACON COLLEGE.

ASHLAND, VA.

Biology is begun in the junior year, only those students being admitted to the course who have had some training in practical physics and chemistry. Physiology is first taken up, instruction being given by lectures with frequent demonstrations before the class. This course occupies 4 hours weekly during half the year, and is followed by a course in botany occupying the same amount of time. Lectures are delivered upon the general anatomy and physiology of plants, illustrated by numerous demonstrations, and there is also a laboratory course, which all students are required to follow. This includes the dissection, description, and classification of plants, together with some practice in the methods of vegetable physiology and histology. Each student is required to prepare a small herbarium.

Zoölogy is taken up in the senior year, 6 hours weekly being devoted to the subject. Up to nearly the close of the session this time is devoted principally to laboratory work, each student being required to make numerous dissections and microscopic preparations illustrating the anatomy of representatives of all the main groups of animals. Theoretical questions are considered toward the end of the course.

The laboratory is newly equipped and contains microscopes and the usual accessories and reagents in abundance to meet the demands made upon it. No special provisions have been made for original work, and as yet none has been done. One floor of the Science Hall, a building 54 by 64 feet, is devoted to the uses of the biological department. This contains the laboratory, museum, lecture rooms, etc. A museum, containing about 400 specimens, and a small herbarium aid the work of the class room and laboratory.

RUTGERS COLLEGE.

NEW BRUNSWICK, N. J.

For admission no requirements are made in science. Biology is taken up at the beginning of the freshman year, the course embracing the subject of human anatomy and physiology, followed by a general course

in comparative zoölogy. Two hours weekly are devoted to this work, with an additional hour devoted to demonstrations. In the third term of the freshman year botany is begun, students being required to make frequent dissections of plants and prepare a small herbarium. Some attention is also given in this course to cryptogamic botany, especially the injurious fungi.

A course in general biology is provided in the junior year, consisting of 5 hours laboratory work per week. This course is at present elective. A large number of types are practically studied with a view to giving the student an exact and comprehensive knowledge of the animal and vegetable kingdoms. Following this is a short course in vertebrate embryology. A course in advanced botany may also be elected in the senior year. This consists of practical work in the microscopic anatomy of plants, with special reference to those subjects having the closest relation to the growing of farm, orchard, and other crops. A course in systematic and economic entomology is also provided. This is especially for the benefit of students of agriculture, and aims at giving the student a general knowledge of insect anatomy and classification, with special reference to the relations of insects to the vegetable kingdom and the economic problems connected therewith.

At present only temporary quarters have been provided for laboratory purposes, and no provisions are made for original work. The early equipment of new quarters is contemplated.

ST. JOHN'S COLLEGE.

ANNAPOLIS, MD.

The work in biology is limited to the freshman class. During the first half-year zoölogy is taken up. In this course no text-book is used, and the work consists of the examination of animal forms, both vertebrate and invertebrate. The order in which these are taken up is regulated solely by convenience, each student being required to furnish his own specimens. These are studied not only as regards their external form, but also their internal structure. Five hours weekly are devoted to laboratory work, and there are occasional lectures in addition.

The second half-year is devoted to botany. In this, special attention is paid to the systematic relationships of plants, and with this in view each student is required to present a herbarium of 50 specimens with a written account of the same. Students are expected to become sufficiently familiar with the characters of twenty or more families to recognize at sight plants belonging to them.

In addition, the course includes elementary studies in structural and physiological botany, the instruction in these subjects being principally by lectures.

For admission an elementary knowledge of physics and physiology is required. The college courses are open to all, but are not required

of classical students. Those who wish to do so may take more extended courses in zoölogy, paying special attention to particular groups of the animal kingdom or making comparative studies of certain systems of organs found in different animals.

For laboratory purposes one large well-lighted room is used, and each student working therein is furnished with a table equipped with a microscope and other appliances needed in his work.

ST. JOHN'S UNIVERSITY.

COLLEGEVILLE, MINN.

No regular course in biology has been arranged. Physiology and botany are taught to small classes, text-books being used in both cases and no laboratory work of any kind being required.

ST. LAWRENCE UNIVERSITY.

CANTON, N. Y.

Work in biology is limited to the second half of the sophomore year in all courses. No preparation in science is required of students applying for admission except a brief course in physiology. The work of the sophomore year consists of prescribed work in human physiology and botany and an elective course in zoölogy. These courses all consist of class-room exercises supplemented by practical laboratory work.

ST. LOUIS UNIVERSITY.

ST. LOUIS, MO.

Biology is not regularly taught except in the post-graduate course. Lectures are given paying attention mainly to those points in which biology comes in contact with psychology.

Courses are occasionally given by advanced students, who, after working through a general biology course themselves, present the subjects considered to their classmates in lectures.

SCIO COLLEGE.

SCIO, OHIO.

For admission to the college classes candidates must have pursued brief courses in physical geography and physiology, as provided in the preparatory department. Each of these courses occupies 5 hours weekly during one term.

In the college classes zoölogy is first taken up during one term, the course being followed by freshmen in the philosophical and scientific departments, and by classical sophomores. This course is practical in character, consisting largely of laboratory work upon representatives of the leading groups. A course in botany, lasting also through one term, is prescribed for students in all courses. This consists of a short

course in systematic botany, followed by a general survey of the vegetable kingdom based upon the practical study of selected types. Each student is required to prepare a herbarium and present a thesis based upon some question which he has especially studied.

SIMPSON COLLEGE.

INDIANOLA, IOWA.

For admission to all courses candidates for the freshman class are examined in physiology, physics, and chemistry, the necessary preparation being given in the preparatory school. The college work in biology begins in the sophomore year, when botany is taken up, the course occupying 5 hours per week during the third term. This includes structural botany and plant analysis, each student being required to analyze numerous plants in the class room and, in addition, to collect and prepare a herbarium of 50 specimens. During the junior year zoölogy is studied for one term, two lectures weekly being given, supplemented by practical work, mainly upon the collections in the museum. Students following the scientific course do additional work in practical biology. As a part of this each student is required to follow a special line of work, generally upon some special group of animals as illustrated by the local fauna. These papers are read before the class, the specimens upon which the paper is based being at the same time exhibited.

The college museum contains representatives of all the classes of animals, a considerable number of corals and skeletons and a valuable collection of invertebrates. There is also a herbarium, containing representatives of most of the local plants.

THE STATE COLLEGE OF KENTUCKY.

LEXINGTON, KY.

Four collegiate courses are provided, the biological requirements in each being different. For admission to the scientific or agricultural courses the candidate must have an elementary knowledge of chemistry, botany, and zoölogy, and into the preparatory course in those subjects provided by the college a considerable amount of practical work enters. The college work in zoölogy and botany continues in the classical course through the latter half of the sophomore year. In the scientific, engineering, and agricultural courses the work consists of a course in botany and vegetable histology in the second half of the sophomore year, and a course in zoölogy and animal histology in the second term of the junior year. A further course in anatomy and physiology, occupying one term, is given to all students. A special course in microscopy is required of scientific students in the senior year.

In all of these courses the necessity for practical work is emphasized, and the student is brought directly in contact with nature wherever

possible. The college possesses limited facilities for laboratory work, having merely an equipment of microscopes, dissecting instruments, etc. It is expected that this will soon be enlarged, and appliances for more advanced work provided.

Admission to the college is usually through the academy, which is under college management. Many of the college courses are begun in the academy, giving such students many advantages over those coming from other institutions. Few of the schools of Kentucky furnish the necessary preparation in science.

STATE UNIVERSITY OF IOWA.

IOWA CITY, IOWA.

For admission to the freshman class in any of the college courses candidates are examined in physics, physiology, and botany. Under the latter head the analysis of 40 species of flowering plants must be presented. Certificates relieving the candidates from entrance examination are accepted from a large number of preparatory schools throughout the State.

All the scientific subjects are elective except in the general scientific course. In this a course in botany is prescribed occupying 5 hours weekly, beginning in the last term of the freshman year and continuing through two terms of the sophomore. Following this there is prescribed for the first term of the junior year a course in general biology, after which are courses in physiology and comparative anatomy. A course in systematic zoölogy is also offered to science students. These studies are all elective to students pursuing the classical or philosophical courses.

Several distinct courses in botany are offered, the first being devoted to a general study of the natural orders, based upon typical representatives. This follows the work of the preparatory school, and special attention is devoted to the more difficult orders, including the amentaceous trees, the grasses, sedges, and ferns. This being completed in the spring term, attention is next given to the autumn phænogamous plants, the compositæ especially, and also the ferns, mosses, and lower cryptogams. During the winter term a course is given in general structural botany and vegetable histology, with special attention toward the end of the course to the development of floral organs.

A special course in the study of fungi is offered to senior science students who have completed the above-mentioned work. Opportunities are also given to advanced students to devote themselves to special work in vegetable physiology and histology, or to single groups of plants, especially the lower cryptogams.

The course in general biology is elective in the junior year. Animal morphology is practically studied during one term, and following this, the winter term is occupied by a course in human anatomy, physiology, and histology, the work being completed by a course in comparative

anatomy which occupies the whole of the spring term. In this connection opportunities for more advanced work are offered to those properly qualified, especially in embryology, but also in physiology and histology.

Systematic zoölogy is offered as an elective to juniors in the general scientific course. The first term is devoted to the systematic relationships of the invertebrates, after which the mammals are considered. The third term is devoted to the study of birds, for which the large collection (about 1,800 specimens) furnish abundant material.

All of the courses mentioned are largely practical, laboratory work forming an important part of them all. In all the more advanced courses a thesis is required which is based upon the individual work of the student.

The teaching facilities possessed by the institution are very considerable. One large building, 112 by 74 feet, and consisting of three stories and basement, is occupied by the department of biology and geology. The first floor of this building contains the laboratories of botany and zoölogy. Each is adapted to accommodate 20 students at once, and the supply of microscopes and other apparatus is abundant for that number. The museum, which occupies the whole of the third floor, has been recently arranged and catalogued, and is now well adapted for practical use. It contains more than 200 specimens of foreign and native species of mammals; about 1,800 specimens of birds, among which are the Hornaday collection containing 125 specimens, mostly exotics; the Bond collection of Wyoming birds, and the Harrison collection of British game birds and birds of prey; collections of fish, reptiles, and mollusca fully illustrate this portion of the fauna of the State, while the invertebrates are represented by several thousand marine forms and a large collection of coleoptera. In addition to these the museum contains a large number of skulls and complete mounted skeletons, illustrating all the orders of vertebrates.

The herbarium contains a large collection of flowering plants from all parts of the United States, and about 100 species illustrating the flora of southern France. It contains also the Lesquereux collection of ferns, consisting of about 500 species from all parts of the world, and about 1,000 species of mosses from Europe and America. There are also collections illustrating the flora of the West Indies, and collections of wood sections illustrating the forest flora of the eastern United States. There is also a full set of Ellis' North American Fungi in twenty-five volumes.

Among the courses leading to the degree of bachelor of science is offered one in which special attention is given to biology. This occupies 4 years, being almost identical with the general scientific course through the freshman year.

The details are as follows:

SOPHOMORE YEAR.

First term.—German, botany, biology.

Second term.—German, botany, physiology.

Third term.—English, botany, comparative anatomy, and physiology.

JUNIOR YEAR.

First term.—Physics or chemistry, systematic zoölogy, English, modern language, political science, philosophy or history.

Second term.—Same as first.

Third term.—Physics or chemistry, systematic zoölogy, geology.

SENIOR YEAR.

First term.—*Two electives.*—Paleontology, special systematic zoölogy, special systematic botany, bacteriology, embryology, field work and preparation of museum material. *One elective.*—French, German, English, Latin, history, political science, philosophy.

Second term.—*Two electives.*—Paleontology, special systematic zoölogy, bacteriology, vegetable histology, animal histology, embryology.

Third term.—Thesis—equivalent to three full studies.

This course has been specially planned to meet the requirements of prospective medical students, but also serves as an introductory course for those wishing to devote themselves specially to the natural history sciences.

SWARTHMORE COLLEGE.

SWARTHMORE, PA.

No requirements in science are made of students applying for admission to the freshman class. The college course in biology is so planned as to extend through the entire 4 years of the curriculum. Four different courses are provided, the full work in biology being required only of science students.

During the freshman and sophomore years two lectures weekly are devoted to the subjects zoölogy and botany. In the zoölogy course the vertebrates and invertebrates are considered in alternate years, attention being given to the anatomy, development, distribution, classification, habits, and economic relations of the various groups. Botany is considered for a short time only in this course, the object being merely to teach the most prominent points in vegetable morphology, to accustom the student to accurate observation, and to the use of the analytical key for the determination of plants.

A more advanced course in botany is given in the junior year, consisting of laboratory work with explanatory lectures. In this the subjects of structural botany and vegetable histology are considered, some work being also done in cryptogamic botany.

The course in general biology extends through the junior and senior years. This is planned for the general student, and its value for those contemplating a medical career is emphasized. The course consists mainly of practical work, instruction being given first in the methods of biological investigation and the examination of minute organisms, proceeding thence to more complex forms. The work in the senior year consists partly of systematic work and partly of studies in comparative osteology and vertebrate dissection. Students in arts and

letters are required to take only the freshman and sophomore courses, but may elect the full course. In addition to the above mentioned there is a course in human physiology in the freshman year, which all students are required to follow.

The laboratory is new and newly equipped with microscopes and other necessary apparatus. In addition there is a conservatory, besides a botanical garden and numerous aquaria for furnishing specimens for laboratory use. The museum is designed solely to supplement the work of teaching. It contains among other things a large collection of skeletons; a collection of birds, including all those found in the State; a large collection of shells, and a herbarium of more than 2,000 species, illustrating the flora of Pennsylvania. In addition to these there is a large collection of invertebrates, together with a considerable number of models and charts illustrating special points in both animal and vegetable morphology.

SYRACUSE UNIVERSITY.

SYRACUSE, N. Y.

Students applying for admission to the freshman class are examined in physiology and physics. Regents' certificates covering these subjects will admit the candidate without examination. Three different courses of study are provided, each leading to a degree, the biological work being the same in all. Physiology is first taken up, the course occupying 3 hours per week through the first term of the freshman year. Biology is resumed in the third term of the sophomore year, physics occupying the greater part of the interval. In this the general principles of biology are taught, and the student is instructed in the simpler methods of practical work. Elective courses of two terms each in botany and zoölogy are open in the junior and senior years to students who have completed these courses. The work is almost wholly practical, consisting of the microscopic examination of plant and animal structures, and the study of the life history of typical forms of plants and animals.

A biological laboratory has recently been equipped containing seventeen compound microscopes and other apparatus in sufficient quantity. The work of teaching is further aided by a museum, containing among other things the "Banks" collection of North American birds; a collection of insects; a large collection of alcoholic specimens of invertebrates and shells, and a herbarium of about 8,000 specimens. In addition to this there is a large stock of material for class use.

TABOR COLLEGE.

TABOR, IOWA.

Three courses of study are provided, each having in addition its own preparatory course. In all the preparatory courses physiology is taken

up during the first year, while during the second year of the scientific preparatory course a short course in physics is prescribed.

In the freshman year of the scientific course phænogamic botany is begun, followed in the first term of the sophomore year by an elective course in cryptogamic botany. Phænogamic botany is followed by sophomores in the classical and literary courses. During the first term of the junior year a course in zoölogy is offered, this being elective to literary students, but required of those following the classical or scientific courses. Physiology is required of all students in the second term of the junior year, while during this term an additional course in determinative zoölogy is open to scientific and literary students.

The botanical work of the freshman year consists mainly of studies in systematic botany. Considerable practice in plant analysis is given, each student being required to prepare a herbarium of 40 specimens. The course in zoölogy occupies one term, and consists of daily recitations illustrated by specimens from the more important classes. The course in determinative zoölogy may be devoted to the classification of the vertebrates, mollusks, or insects, at the option of the student. Physiology is taught during one term by daily recitations, supplemented by frequent demonstrations.

The museum contains a considerable number of marine forms, chiefly invertebrates, while the herbarium contains a complete collection of Iowa plants, and in addition collections of ferns from southern India and the Appalachians and algæ from the Atlantic Ocean.

TRINITY COLLEGE.

HARTFORD, CONN.

Four different courses of study are provided, but in none of them is any science required for entrance. In these courses the only biological work offered is a course in general biology, consisting of one weekly exercise during one half-year in the practical study of animal forms, and a course in which 2 hours weekly during one half-year are divided between botany and zoölogy. In the arts course these are both elective in the junior year. In the scientific course biology is required in the sophomore year and zoölogy and botany in the junior. In the course in letters biology is required in the sophomore year, while zoölogy and botany are elective in the junior.

The department is at present in process of formation, and considerable changes will be made during the next year. The general plan will be to provide a primary course, mainly practical, covering types of the invertebrates, which will be required in all courses. Elective courses, required of scientific students, will be offered in general biology, physiology, etc., and furthermore, advanced electives will be offered in vertebrate anatomy and embryology. The laboratory facilities, which at present are ordinary, will also be extended.

At present the only means of illustrating the biological courses are a collection of mounted skeletons, a series of alcoholic preparations, and a collection of glass models of invertebrates.

TUFTS COLLEGE.

COLLEGE HILL, MASS.

No requirements in science are made of students applying for the freshman class.

During the second half of the sophomore year students may elect a course in physiology occupying 3 hours weekly, and in the junior year botany and zoölogy may be chosen. Those who have finished this work may continue the subjects in the senior year, and may also elect a course in general biology. This consists of laboratory work mainly, 8 hours weekly being devoted to it.

Abundant facilities are provided for elementary work. Each student is provided with a microscope and dissecting and imbedding materials. The laboratory occupies a portion of the basement of the museum building. It is fitted with the necessary tables and cases, supplied with gas and water, and contains also numerous tanks and aquaria for breeding and preserving aquatic animals and plants.

TULANE UNIVERSITY.

NEW ORLEANS, LA.

For admission to the freshman class in the classical course no knowledge of science is required. Students applying for the scientific courses are expected to have an elementary knowledge of chemistry and physics.

The course in biology, which is required only in the scientific course, runs through the freshman, sophomore, and senior years. In the freshman year a course in general biology is given, consisting of one lecture and two laboratory exercises weekly. In the sophomore year a course is first given in human physiology, consisting of three exercises per week for 6 months. In connection with this course abundant demonstrations are given and histological work done by the class. The last 2 months of the sophomore year are devoted to general botany, with practice in plant analysis. In the senior year 6 hours weekly are devoted to laboratory work, and the subjects of embryology, systematic zoölogy, and cryptogamic botany are considered. Lectures are delivered in connection with each of these subjects, but special emphasis is laid upon laboratory work, in which the methods of histology are thoroughly practiced. In the classical course there is no biological work. In the literary course it goes no further than the work of the freshman year.

The laboratory is supplied with microscopes, aquaria, and all other necessary apparatus, including some physiological apparatus. The herbarium contains over 10,000 specimens, representing about 4,000 species of native and foreign flowering plants, while there are also

special collections of Louisiana plants. The zoölogical collection includes representatives of all the classes, and most of the important orders of animals, as well as numerous skeletons and models illustrating the lower forms of life.

UNION COLLEGE.

SCHENECTADY, N. Y.

No requirements are made in science of students applying for the freshman class. In the scientific course the biological work begins in the third term of the freshman year, with a course in practical biology. This course is designed to teach the student proper methods of work, and at the same time impart a knowledge of the fundamental properties of living bodies. Botany is also prescribed for scientific students in the third term of the sophomore year. In this attention is paid to the fundamental principles of plant biology as well as systematic botany. The studies of the junior year are required of classical as well as scientific students, the subjects presented being physiology and zoölogy. In these there are lectures and text-book recitations, together with frequent demonstrations. A laboratory course is open to seniors. This consists of practical work in the examination of animal forms, beginning with those lowest in the scale and proceeding on in the order of increasing complexity to the highest. A careful dissection of one of the higher mammals is made during the second term, while the third is devoted to work in practical botany.

Facilities are provided for the practical work which is required in connection with all these courses, microscopes, dissecting instruments, and other requisites being furnished.

The zoölogical museum contains more than 15,000 species. Of these about 1,600 are vertebrates, and the remainder include representatives of all the lower subkingdoms, the collection being specially rich in worms and mollusca.

UNIVERSITY OF CALIFORNIA.

BERKELEY, CAL.

For admission to the freshman class of the scientific course an elementary knowledge of physics, with some practical work, is required. In addition the candidate must offer either chemistry, botany, physiology, or mineralogy, with practical work. No requirements in science are made of those applying for the classical course.

The undergraduate course in botany occupies 3 hours weekly during one year. Attention is first directed to general vegetable morphology with practical exercises in plant analysis. Economic botany is then taken up with special reference to plants useful or injurious to agriculture in California. This course is prescribed in the sophomore year to students in the college of agriculture, but elective to classical and lite-

rary students in their senior year. A further course in advanced systematic botany is open to those students who have finished the work above mentioned and wish to carry their studies still farther.

A course is given in comparative physiology occupying 2 hours weekly during one year. In this, attention is given first to the organs and functions of animal life, the nervous system, sense organs, muscular and skeletal systems, after which the digestive, circulatory, respiratory, and excretory organs are considered. This course is elective to students in the college of letters, but prescribed for all others in their junior year.

A course in economic entomology is prescribed for students in the college of agriculture in their junior year. Studies are made in orchard and field of various injurious insects, and the insecticides used in overcoming them.

A room has been partially equipped as a laboratory, but at present it is not equal to the demands made upon it. No laboratory work is required of students, and at present the only work done is what may be individually undertaken. At present the whole department is in a transitional state. There is a real demand for practical instruction in biology, but the department being combined with that of geology it is impossible for the present to give it the attention that it needs. It is expected that within a year a special chair will be created. A new laboratory will be equipped at that time and such other steps will be taken as may be needful to supply the demands.

The museum contains a botanical collection consisting of a large number of Australian plants, and a collection of native woods, cones, etc. The private collection of the professor of agriculture, containing about 12,000 species, is also available to students. The zoölogical collection contains a full representation of the general fauna of the Pacific coast, and in addition a type collection of shells and a series of mounted skeletons. There is also a collection of coleoptera numbering about 2,000 species, while there is in addition a collection of lepidoptera in process of formation.

UNIVERSITY OF CINCINNATI.

CINCINNATI, OHIO.

Admission requirements for the freshman class in the arts course include human physiology. Students applying for the scientific course are expected to have in addition an elementary knowledge of botany, chemistry, and physics.

In the arts course physiology is the only biological subject presented, the course occupying 2 hours weekly through the second year. This course is also required of students in the literary course in their first year, with an additional course in either biology or geology in the fourth year, occupying 4 hours weekly during the second term. The course in physiology above mentioned is required in each of the courses leading

to the degree bachelor of science, one of which courses is especially devoted to biology. This course, in which the peculiar features begin in the second year, is introduced by a course in general biology, in which invertebrates and cryptogams are studied. Four hours weekly are devoted to lectures and laboratory work. In the third year the comparative anatomy of vertebrates receives attention during 5 hours weekly, and in the fourth year the student may elect advanced work in either zoölogy, botany, or paleontology, with reference to a thesis. The student receives his principal training in methods in the second year, is thrown increasingly on his own resources in the third, and is made quite independent during the fourth. The course in physiology is conducted by lectures with parallel reading, and occupies 2 hours weekly during 1 year. The third-term is specially devoted to the nervous system, as a preparative for a course in psychology.

Facilities for laboratory work have recently been greatly extended, and are now ample for a small number of students.

UNIVERSITY OF COLORADO.

BOULDER, COLO.

Students applying for admission to the freshman class in the courses leading to the degrees bachelor of arts and bachelor of philosophy are not required to present any scientific subject for examination. Physiology and physics are required of students applying for the degree bachelor of letters, while those entering the scientific course are examined in physics, chemistry, and biology. The latter subject is at present taught in but a few schools of the State, but in a year or two will probably be made a part of the work of all the high schools. Students are admitted by certificate from the Denver high schools and all others that carry out the course of study prescribed by the State Teachers' Association.

All of the courses leading to degrees are partly prescribed and partly elective. In all courses except that leading to the degree bachelor of science biology stands on the same footing with other scientific subjects taught, and may be elected at any period in the course. In the scientific course biology is elective with chemistry in the freshman year, while in the junior year the student must select any two, and in the senior year any one of the following: Mathematics, physics, chemistry, and biology.

The biological courses which may thus be chosen are general biology, botany, and zoölogy. Each course occupies 1 year, and includes three lectures and 4 hours' laboratory work each week. Further courses, occupying half the year and consisting almost entirely of laboratory work, are offered in comparative osteology, comparative embryology, and vegetable physiology and histology.

The biological laboratory is situated in the main building. It is fitted up with worktables and contains ten compound microscopes, in addition to microtomes and all needed glassware. Extensive improve-

ments in the equipment of the laboratory are contemplated. The museum contains a series of typical vertebrate skeletons, as well as a considerable collection of alcoholic invertebrates prepared at the Naples laboratory. Local collections have also been made. The botanical collection includes about 1,500 species of flowering plants, as well as numerous cryptogamic forms.

UNIVERSITY OF DAKOTA.

VERMILLION, S. DAK.

All candidates for admission are required to pass an examination in elementary physiology, while those applying for the scientific course are further examined in elementary physics and physical geography. The necessary instruction in these branches is given in the preparatory department, as well as in numerous high schools, from which students are admitted on certificate.

In the regular courses leading to degrees all the scientific subjects are elective, the classical and philosophical courses requiring one scientific course with daily exercises through 1 year, while the general scientific course requires two scientific subjects of the same length. The biological subjects which may be chosen are general biology, zoölogy, and botany. The first named consists of daily recitations and laboratory exercises through 1 year. The object of the course is to give a broad general foundation based upon the practical study of typical forms. The course in zoölogy consists of daily recitations and laboratory exercises designed to give the student a knowledge of the general types of animal structures. Lectures are given on animal physiology, and exercises in the study of vertebrate anatomy are designed to familiarize the student with the methods of scientific investigation. A course in botany, consisting of daily exercises during the spring term, is given. This work, designed to supplement the work of the preparatory department, consists of a more advanced study of the morphology of flowering plants, supplemented by lectures on the history of botany, and original work. Courses in comparative anatomy and embryology are given, each consisting of daily laboratory work during one term, and in addition to this is a course in microscopic technique occupying 3 hours weekly during one term. A noteworthy feature of the course is the seminary, which has two weekly sessions of 2 hours each through the year. This is composed of the more advanced students only, and meets for the discussion of current biological literature.

No laboratory has yet been provided, the recitation rooms being fitted with tables for dissection and microscopic work. Five microscopes with the usual attachments, an automatic microtome, and apparatus for microphotography constitute the equipment. The museum contains a small collection of marine animals and numerous specimens illustrating the fauna of Dakota, especially the birds, mammals, and fishes.

BIOLOGICAL TEACHING IN THE
UNIVERSITY OF GEORGIA.

ATHENS, GA.

The course in biology begins in the sophomore year and continues to the end of the senior. Students in the arts course are required to take but half of the senior course. Each class meets the professor twice weekly for lectures or recitations, and in the junior and senior years there is in addition one weekly exercise in the laboratory.

The work of the sophomore class begins with an elementary course in human physiology, consisting of lectures and demonstrations through about two-thirds of the year. The aim of this course is primarily to give information of practical value from the standpoint of personal hygiene, but also to give as much training as possible in the methods by which this knowledge was originally obtained. The remainder of the year is devoted to botany, a few introductory lectures being first given, after which the time is devoted to practical work in the analysis of flowering plants.

Beginning with the junior year the course assumes a new character, special emphasis being laid upon the laboratory work. The aim is to cultivate habits of self-reliance and independence of thought, and to this end the student receives abundant practice in the scientific methods of observation, experiment, and reasoning. The subject-matter upon which this training is based is a series of familiar plants and animals. No attempt is made to cover the entire field of zoölogy and botany, but the student is supplied with specimens and then placed as far as possible in the condition of "the original discoverer." The lectures are designed not so much to impart information to be verified in the laboratory as to suggest lines for independent investigation. As each type is mastered it is made the basis of a description of the class which it represents considered from the standpoint of function and development as well as structure.

This course in general biology is concluded about the middle of the senior year, after which the time is devoted to histology, embryology, and general questions of a theoretical interest.

The work of post-graduate students varies from year to year and may be altered to suit the special needs of students. For the present year courses are offered in embryology, special topics in physiology, and the histology of the sense organs.

The laboratory is in temporary quarters and is inadequate to the demands made upon it. The equipment consists of the usual glassware and eleven compound microscopes, one of these being suitable for work in bacteria. It contains also a microtome, culture oven, aquarium, and some apparatus for physiological experiments. The museum is scarcely begun, containing but a few hundred specimens, most of which have been presented by the U. S. National Museum. Local collections both of the flora and fauna are in process of formation.

No requirements in science are made of those entering the freshman class, the condition of the preparatory schools being such as to render this impossible.

UNIVERSITY OF KANSAS.

LAWRENCE, KANS.

The relations existing between this institution and the high schools of the State are such that students completing the prescribed courses of the latter are received without examination. Most of these schools furnish elementary instruction in science of a good quality, but in the entrance requirements as now arranged no science is required.

The courses leading to the bachelor's degree are six in number. In all of these the studies of the first 2 years are prescribed, while the work of the junior and senior years is elective. The choice of electives is made under the condition that each student must select one major study, to which 5 hours weekly are devoted during 2 years; two minor studies, which may be nearly related to the major, and each of which occupies 5 hours weekly during 1 year, and two free electives occupying the same length of time but in a different department.

In the freshman class of all courses botany is prescribed in the second half-year. In this, attention is mainly given to systematic botany, and the laboratory work accompanying gives each student practice in collecting and analyzing plants. Students in the scientific courses follow a course in histological botany during the first half of the sophomore year, while in the second half a laboratory course in general zoölogy occupying 2 hours daily is prescribed for students in all courses except two especially devoted to languages.

The courses open to juniors and seniors consist mainly of laboratory work, usually 2 hours daily, and each is completed in one half-year. Courses are offered in histological and physiological botany, while the student wishing to devote special attention to animal life may elect human and comparative osteology, and vertebrate or invertebrate anatomy. A general course is given in mammalian anatomy, followed by a special study of the anatomy of the nervous system. A course is provided in human physiology with laboratory work accompanying. Facilities are also offered to those wishing it to pursue the study of entomology.

The headquarters of the department are in the Snow Hall of Natural History, a building completed in 1886 at a cost of \$50,000. This building consists of two full stories, each 16 feet in height, with attic and basement. The entire building is devoted to work in natural history, and furnishes for the departments of biology and geology the necessary lecture rooms, laboratories, and museums. One large room, 36 by 86 feet, is used as a laboratory for elementary work in botany, and three rooms of the same size are used for museum purposes. Three rooms, 24 by 28 feet 9 inches, are used as laboratories for general biology, structural

botany, and anatomy, while there are in addition special rooms for entomology and general zoölogy, besides numerous workrooms for curator's use.

The equipment of the various rooms is well adapted to the uses for which they are intended, all the necessary apparatus being furnished in abundance.

The collections in the various museums are of considerable size. A herbarium of more than 4,000 species of flowering plants all catalogued and arranged is available, also a small collection of cryptogams. The collection of insects includes about 10,000 species, many of which are of unusual value, and the collection of marine invertebrate forms numbers about 1,000 species. The vertebrates are mainly represented by birds and mammals. Under the former head are about 1,500 specimens representing more than 500 species, while the mammals include most of the prominent forms found in the United States. The museum also contains a considerable number of mounted skeletons of birds and mammals.

UNIVERSITY OF MICHIGAN.

ANN ARBOR, MICH.

This institution is a part of the public educational system of the State, and bears such a relation to the high schools of the State that a large number of these may enter students without examination.

The admission requirements for the freshman class in the bachelor of arts course include physics, in which course the student must have done considerable practical work, and botany, including vegetable anatomy and physiology, together with the analysis and written description of 50 species of flowering plants. Students applying for the degree of bachelor of science may offer either chemistry, geology, zoölogy, physiology, or astronomy, but in the one chosen a certain amount of practical work must have been done. Candidates for the degree of bachelor of letters must offer physics and botany as above and any three of the additional subjects mentioned.

All of the courses of study leading to degrees are largely elective, each degree having but a small proportion of its entire work prescribed. In the courses leading to the degrees of bachelor of arts, bachelor of philosophy, and bachelor of letters no science is prescribed. In the general scientific course the student is required to take not less than one full course (five weekly exercises during half a year) in some one of the biological sciences, and must elect five full courses in either the biological or physical sciences. A special course, leading to the degree of bachelor of science, in biology has been arranged, in which zoölogy, botany, and physiology are the most prominent subjects. During the last year of this course opportunities for original investigation are given to students.

Courses are offered in general biology, zoölogy, botany, and physiology, and from these the student may make his own selection.

The course in general biology is ordinarily taken first and occupies 1 year, there being two lectures weekly, with daily laboratory exercises occupying from 10 to 15 hours per week. A course is given in systematic zoölogy, consisting of five lectures weekly through the year, the time being equally divided between vertebrates and invertebrates. A course consisting mainly of laboratory work is also given in the systematic study of vertebrates, and another of a similar character is devoted to the invertebrates. These courses are largely individual, there being but few lectures. In addition to these, more advanced courses are offered, the first being a study of the structure and development of animal types not included in the general biology course. This runs through the year, and consists of one lecture weekly, with daily laboratory work. A course in mammalian anatomy and another in comparative vertebrate anatomy may be chosen during the first half-year, each consisting of two weekly lectures with daily laboratory work, and following these in the second half-year is a course in vertebrate and comparative embryology, occupying the same time. Those who are prepared may also elect original work in animal morphology, devoting to it as much time as they desire.

The introductory course in botany is devoted to the study of the structure and development of typical plants. This consists of one lecture weekly with daily laboratory work through the year. A course is also given in vegetable histology and physiology consisting mainly of laboratory work running through the year. Cryptogamic botany is also offered, the course consisting of laboratory work with occasional lectures through the year. During the latter part of this course special attention is paid to those fungi which cause diseases in cultivated plants. Those who have completed this work may take a more advanced course, devoted to original work both in the study of cryptogams and phanerogams. Special facilities are given to those wishing to do advanced work in the study of fungi and vegetable physiology.

A course in animal physiology is given consisting of three lectures and one laboratory exercise weekly.

Separate laboratories are provided for botany, animal morphology, and physiology. The first named is equipped with thirty-five compound microscopes, and contains in addition all the necessary reagents and supplies for microscopic work, as well as a considerable amount of physiological apparatus. The morphological laboratory is also well equipped with microscopes, and the necessary imbedding and cutting apparatus, as well as incubators, aquaria, etc. The physiological laboratory is thoroughly equipped, and offers every facility for elementary work and original research. One large room is devoted to class instruction, and in addition there are an apparatus room, a dark chamber for optical experiments, an incubation closet, and a workshop. The instrumental equipment of the laboratory is unusually complete, containing most of the apparatus needed in general physiological research.

The zoölogical collections include about 110,000 specimens. There is a full series illustrating the fauna of Michigan and other northern and western States. The animals of the Pacific coast are well represented, and large additions from foreign countries have also been made. Included in this is the Beal-Steere collection, consisting of 25,000 insects, 1,500 shells, 8,000 birds, and numerous representatives of other groups, about 60,000 specimens in all.

The botanical collections include principally flowering plants and fungi, with a small collection illustrating the subject of economic botany. The flowering plants include the entire flora of Michigan, so far as described, as well as several notable collections of flowering plants made in various parts of the world, and presented to the university. The fungi number about 3,000 specimens, including dried and alcoholic material, and there is also a large number of specimens of woods, including most of those found in the United States. The botanical museum includes in all about 70,000 specimens.

UNIVERSITY OF MINNESOTA.

MINNEAPOLIS, MINN.

Students applying for the freshman class in any of the courses must pass examinations in elementary physiology and physics. Those coming from certain of the Minneapolis schools and about fourteen high schools through the State are admitted without examination on presenting certificates from the institutions in question.

In the classical section botany is the only work required, this course occupying the third term of the freshman year, and consisting of four weekly exercises, devoted to the leading characteristics of the algæ, fungi, mosses, and ferns, and to plant physiology. In the junior and senior classes most of the scientific work is elective. Physiology and histology and physiological botany may be chosen in the junior year. Each course occupies 4 hours weekly, devoted to lectures and laboratory work. A special course in mycology is also given during one term of the junior year. During the senior year a course in animal morphology is open to those who have had the preliminary training afforded by the courses already mentioned.

In the scientific course the student may choose between vegetable and animal biology in the third term of the freshman year. In vegetable biology the work begins with a study of plant cells, and proceeds through the fungi and higher cryptogams to the anatomy, physiology, and systematic relations of flowering plants, the course continuing through the sophomore year. The course in animal biology begins with a thorough drill in the use of the microscope, camera, micrometer, etc., and during the remainder of the term the student is occupied with a general study of the properties of living matter, passing then to the protozoa. As a test of his knowledge each student is required to make

a clay model of an infusorian, showing the details of internal structure. During the sophomore year there are two lectures and three laboratory periods of 2 hours each. This time is spent in a general survey of the animal kingdom, closing with a course in embryology, devoted especially to the development of the chick, frog, and snail. During the year each student is required to make several permanent anatomical preparations illustrating special points, and also several models showing the development of certain organs. Some work in systematic zoölogy is also required of each student, the insects, fishes, or birds usually being made the basis of this work. In the junior and senior years the same choice is offered as in the classical course. The student electing botany devotes his attention to the plant cell, its protoplasm, nucleus, etc., and then proceeds to the physiology of nutrition, metabolism, and growth. The course in physiology and histology consists of two lectures and 6 hours' laboratory work weekly, devoted to a general study of the various organs in the living body, their gross and minute structure, and their mode of action. The course in animal morphology, elective in the senior year, is not fixed, but consists of laboratory work and reading in any direction that the student, properly qualified by his previous training, may desire.

In the agricultural course, the same electives are offered as above, with an additional course in entomology occupying 4 hours per week during the third term of the junior year. In this course the general characters of insects are presented with special reference to injurious families, and a detailed study is made of numerous individual forms, the destructiveness of which renders them specially conspicuous.

The laboratory is situated in Pillsbury Hall, a large building donated by ex-Governor John S. Pillsbury. It affords accommodations for forty students, containing microscopes in sufficient number for their individual use, and in addition all the apparatus needed for dissecting and embryological work. It also contains physiological apparatus in sufficient quantity to illustrate the general course, but no special provisions have been made for advanced research.

The museum contains numerous zoölogical specimens, alcoholic preparations of invertebrates from the Atlantic Ocean and Bay of Naples, as well as many of the birds and mammals illustrating the local fauna. In addition to this there are numerous skeletons, and models in wax and papier-maché, illustrating special points in the anatomy of both vertebrates and invertebrates.

UNIVERSITY OF MISSISSIPPI.

UNIVERSITY, MISS.

The biological work of this institution is limited to the freshman year, the time being equally divided between zoölogy and botany, and 5 hours weekly being devoted to each.

Zoölogy is studied by means of text-book exercises with practical work accompanying. Each student is also required to make a collection of representatives of some common group of animals and specially study the life history of a selected form.

The course in botany is so conducted as to give the student a knowledge of the parts of flowers and their relations and considerable practice in plant analysis. Vegetable physiology is also briefly taught.

The laboratory equipment consists of a few compound microscopes, together with the necessary reagents for staining and mounting. There is also a small collection of specimens available.

The course in biology is required of scientific students, but elective to others, no scientific preparation being required for entrance.

UNIVERSITY OF NEBRASKA.

LINCOLN, NEBR.

Applicants for admission to the freshman class of the classical course are not subject to examination in any scientific branches. Those applying for the scientific, literary, engineering, or agricultural courses are relieved from Greek, and in its stead are examined in chemistry, physics, and botany. In connection with all of these, practical work must have been performed; and under the latter head a herbarium, containing 100 specimens, must be presented. The necessary instruction is furnished by many of the high schools of the State, there being twelve such schools from which students are admitted on presentation of their diplomas.

In the academic course no work in science is prescribed, but the student may, without restriction, elect any of the subjects prescribed for the scientific courses. In the general scientific course zoölogy and botany are placed in the junior year, 4 hours weekly being devoted to the former, and 2 to the latter, subject, with 5 hours additional for laboratory work. In the course in zoölogy the invertebrates are first studied practically, after which the vertebrates are considered. A course is then given in comparative zoölogy, with an introduction to systematic zoölogy and field work, each of these courses occupying one term. In botany attention is first given to vegetable anatomy, then to vegetable physiology, following which is a course in the special anatomy and physiology of cryptogams.

Several scientific courses of a special character are offered, one devoting attention to botany, another to zoölogy, and a third to agricultural biology.

In the botanical course the work above mentioned in botany is done in the freshman year. In the sophomore year the work in zoölogy above mentioned is done, and in addition there is a special course in the anatomy and physiology of the phanerogams, consisting of two lectures and 5 hours' laboratory work weekly. The work of the junior

and senior years is of a more special nature, including a study of the structure and physiology of some one plant, the comparative anatomy of special tissues or organs, and the study of some selected group of plants with the preparation of a catalogue. In the senior year the preparation of a thesis, based on the work of the student, is required.

In the zoölogical course the work of the freshman year is the same as in the botanical course, and in the sophomore year the work is the same, except that physiology is substituted for botany, human and comparative physiology being treated for 2 hours weekly during the year. The zoölogical work of the junior year consists of a course in the general structure and development of insects, occupying 3 hours weekly during two terms; a course in the comparative histology of vertebrates, occupying the same time; a course in general conchology, occupying 3 hours weekly during one term, and a course of the same length on the structural and systematic relations of fishes and reptiles. In the senior year the zoölogical work consists of advanced comparative anatomy and histology, together with the systematic study of any selected group of animals. In connection with this a thesis is prepared.

In the course in agricultural biology the work of the freshman and sophomore years is the same as in the course in zoölogy. In the junior year the study of insects is pursued as in that course, and there is a further course in comparative embryology occupying 2 hours weekly. In the senior year there is a course in general comparative anatomy and physiology, to which 5 hours weekly are devoted.

In addition to the above specified courses, facilities are offered for more advanced post-graduate work in all the departments of biology. No definite lines of work are followed, but special work is laid out according to the desires of the student, and every facility is given him for bringing his work to a successful issue.

Five separate rooms are devoted to laboratory uses. One of these is fitted with the usual apparatus, microscopes, micrometers, injecting apparatus, etc., needed in general zoölogical work, while another room is similarly arranged for the study of vegetable morphology. The morphological laboratory is equipped for investigation in the lines of anatomy, physiology, histology, and embryology. The supply of apparatus is abundant, there being in all about fifty compound microscopes, besides camera lucidas, microtomes, and all the ordinary apparatus. There is also considerable apparatus for physiological work, including recording cylinders, chronographs, tambours, electrical apparatus, etc. Two rooms, one devoted to entomology and the other to pathology, have been fitted up for the special work of the experiment station, but are open to all students who are properly qualified.

The museum contains numerous representatives of the different animal groups, among which may be mentioned alcoholic collections of lower marine invertebrates and mollusks, mounted specimens of native birds and mammals, as well as local fish and reptiles. There are also

numerous skeletons and skulls of vertebrates, and microscopic preparations of smaller animals. There are, in addition, a general collection of about 150,000 specimens belonging to the professor, and a collection of about 8,000 species of insects belonging to the experiment station, both of which are accessible to students.

The herbarium contains almost a full representation of the plants of the State, and in addition numerous valuable sets of cryptogamic plants prepared by eminent specialists. These include in greatest number, mosses, hepaticæ, fungi, and lichens, about 25,000 specimens in all. In addition, the agricultural museum contains about 1,200 specimens of grains, grasses, forage plants, woods, etc.

No course in biology is offered.

UNIVERSITY OF NORTH CAROLINA.

CHAPEL HILL, N. C.

The study of biology is begun in the first term of the first year in the science courses. During this term each student devotes 2 afternoons each week to the practical study (in the laboratory or field) of typical animal forms, and there is one weekly lecture which supplements this work. During the second term the class is divided into three sections. One section devotes special attention to microscopic technology, as applied in medicine and surgery. The second section takes up the subjects of general ornithology and taxidermy. In the third section students continue the work in general biology, begun in the first term, by studying in detail higher animal forms.

During the second year three lectures weekly are delivered on physiology. In this, special attention is given to the comparative physiology of respiration and circulation, and frequent demonstrations illustrating many of the fundamental points are given. The second term of this year is divided between zoölogy and botany, three lectures weekly being given to each during half the term. The course in zoölogy consists largely of practical work, while the course in botany is of an elementary character, intended for those who wish afterwards to do more advanced work.

In the junior and senior years elective laboratory courses are offered in general morphology and embryology, 2 afternoons being devoted to each during one term. Opportunities are also given to those wishing to do advanced work in systematic botany, the work consisting largely of a study of the local flora.

In all of these courses instruction is given mainly by lectures, to which about one-third of the entire time is devoted, the remainder being devoted to laboratory work.

The lecture course is required of all students in the course in arts, philosophy, and science, while the laboratory work is required of scientific students only.

Several rooms are devoted to the uses of a laboratory, the largest being 55 by 16 feet. These are fitted with tables and all necessary apparatus for staining, injecting, and cutting tissues, and with microscopes and a complete outfit for photographing microscopic preparations.

The smaller rooms are for more special work. These are either equipped with apparatus from the general stock or special pieces are purchased as needed.

For entrance no requirements in any branch of science are made, the reason being that the schools of the State furnish little or no preparation in science.

UNIVERSITY OF PENNSYLVANIA.

PHILADELPHIA, PA.

Few institutions in the country give greater prominence to the study of biology than this. The teaching force in the school of biology alone consists of eight professors and four assistants, and with the large, well-appointed laboratory, and other conveniences and appliances for teaching, the opportunities offered are somewhat unusual. The school has its own faculty and is, to a great extent, a separate department; yet the courses offered are open to all students in any of the other departments of the university, and may enter into any of the courses leading to degrees.

One of the college courses leading to the degree of bachelor of science has been so planned that considerable attention may be given to biology during the whole 4 years. Students applying for admission are required to pass an examination in physics, botany, zoölogy, and physiology. A special course, occupying 2 years and not leading to a degree, has been planned for the benefit of prospective medical students who are desirous of working in those branches of biology having a more direct bearing upon medicine, and who are unable for any reason to complete the full course.

The "4-years' course in natural history" begins with a course in general biology, occupying 6 hours weekly through the freshman year. In this, lectures are subordinated to laboratory work, and the entire course is so conducted as to give the student a broad general training, based on the study of numerous living and preserved forms of plant and animal life, and, along with this, abundant practice in the methods used in biological investigation and training in the delicate manipulations involved. At the beginning of the course considerable time is therefore devoted to the acquisition of careful habits of work and a thorough understanding of the methods and the apparatus employed. During the course those methods are used in the study of about twenty-five organisms, and, in addition, each student is required to present some piece of special work, dissections, diagrams, microscopic preparations, etc., as an evidence of his practical acquaintance with these methods.

In the sophomore year all the scientific courses are elective, those offered in biology being (1) zoölogy, the course occupying 1 hour weekly through the year, (2) a laboratory course of 6 hours weekly running parallel to this, and (3) structural and systematic botany. The course in zoölogy is general, attention being given first to invertebrates, then to vertebrates. The laboratory course in animal morphology serves to fix the details and give additional practice in methods. The invertebrates are chosen first because of their important bearing upon the problems offered by a study of higher forms, as for example, their relations to the embryology of vertebrates, and in reality the phylogeny of all the organs found in vertebrates. Practical considerations are not overlooked. The life histories of injurious animals, parasitic worms, and insects are presented with sufficient fullness to form a basis for methods of treatment. The study of animals which may serve as food, the methods of breeding and improving varieties, are all considered in the practical course. Vertebrates are considered in the same way, proceeding from the simple to the more complex, sufficient examples being in every case considered to give the student a clear idea of what the vertebrate structure is and what modifications the different organs are subjected to as they pass from the lowly, primitive forms up to those which have diverged in various directions to adapt them to special modes of life.

The course in structural and systematic botany consists of lectures and laboratory work, occupying 5 hours weekly, and so planned as to give the student a knowledge of the most obvious facts and conditions of plant life. The separate organs of plants are first considered, both as regards their gross and minute structure, after which their functions are considered and their relations to the same organs in other plants. General systematic botany, with special reference to the phænogams, occupies the second half of the sophomore year. In this work the attempt is made to secure the largest results as a means of education. Plants are examined and analyzed in order to exercise the student's powers of observation and generalization. Finding the name of a plant is treated not at all as the aim of the study, but merely as a control, since any erroneous observation is at once detected by the failure to find the name. The study of the various orders and the detection of the unity of plan running through the vegetable kingdom is thus made to depend upon the practical work of each student mainly, only so much being presented in lectures as is necessary to systematize and supplement this work.

During the junior year courses are offered in histology and embryology as well as in structural and cryptogamic botany. To the former course one lecture and 6 hours laboratory work are devoted each week. Instruction is given in the most approved methods of histological technique, and most of the tissues making up the bodies of animals widely separated in the scale are examined. The study of embryology begins

with the cleavage of the egg, and proceeds through the subsequent stages with sufficient minuteness to give the student a fairly complete idea of the different methods of development found in the different animal groups.

The botanical work follows that offered in the sophomore year. The cryptogamic plants are specially studied, beginning with the lowest and proceeding to the highest forms, with a view to pointing out those principles and relationships which give unity to the whole group of flowerless plants.

During the senior year the student may pursue any of the studies offered in previous years, with physiology in addition, or may follow special advanced courses in vertebrate or invertebrate morphology, mammalian osteology and anatomy, histology and embryology, physiological and economic botany.

The course in physiology occupies 2 hours weekly through the senior year, consisting of lectures and demonstrations. This course is largely practical, being so planned as to give the student an idea of the position, form, and uses of the various organs of the body, and to give him a rational basis for laws of health.

The advanced courses in animal morphology differ from the elementary in being devoted to the investigation of special points in the life history or anatomy of certain animals. The work is therefore purely individual and special, and the instruction given is of an informal nature suited to the special requirements of the case.

The courses in mammalian osteology and anatomy are designed to give a minute knowledge of the skeletons and general structure of the mammalia. Beginning with some familiar example the student puts all the methods of anatomical study into practice until he has made himself master of all the details of its structure. From this he may pass on and consider in a less detailed way forms that are not so familiar.

In the advanced courses in histology and embryology no new features are introduced, save that the work is purely individual, a special line of work being planned for each student and instruction being given in an informal way as required. The botanical work of the senior year consists of physiological and economic botany. This work may be adapted to meet special needs, attention being given to medicinal plants or examination of vegetable foods. In this course, too, students may devote time to the microscopic study of woods, giving attention to the relations existing between the microscopic characters of different woods and their strength, weight, and other qualities of practical value.

The laboratory building was erected in 1884. It is a three-story structure, 82 by 47 feet, and contains twenty-eight well-lighted work rooms, besides the necessary lecture rooms, offices, and museum rooms.

The workrooms are supplied with gas and water and with all the apparatus necessary in the work for which they are designed. Compound and dissecting microscopes are provided in sufficient abundance

for each student to have one for his own use, and all other apparatus ordinarily needed is furnished on the same scale.

The museum at present is merely a teaching collection. It contains a large series of skeletons for use in connection with the course in comparative osteology, and a number of alcoholic preparations illustrating various points in the anatomy of vertebrates. Supplementing this is a large collection of models in glass, papier maché, gelatine, and wax, which illustrate the courses in anatomy, histology, and embryology. The museum also contains a large number of mounted and alcoholic specimens of various vertebrate and invertebrate types, which illustrate the course in general zoology. In addition to these may be mentioned a large set of embryos preserved entire, and many others prepared for microscopic study, both vertebrate and invertebrate.

The herbarium is of large size and great value. It includes a set of about 6,000 specimens illustrating the flora of the region about Philadelphia, and about 50,000 specimens from all parts of the world. It also includes most of the native species of ferns, mosses, and lichens, and more than 2,000 species of fungi, all determined by leading authorities.

As further aid in this department there is a greenhouse and a botanical garden, both of sufficient size to furnish material for class work in abundance, and to afford a place for such experiments in vegetable physiology as can not well be made in the laboratory.

UNIVERSITY OF ROCHESTER.

ROCHESTER, N. Y.

No scientific subjects are required for admission except to the scientific course, in which case an elementary knowledge of botany and physiology is expected. Biological instruction is given by means of lectures, laboratory exercises, and recitations. Four distinct courses of biological work are given, and these are placed at different times in the different courses.

A course in general biology gives an introduction to the modern methods of biological research. It includes a study of typical plants and animals, beginning with low forms and continuing to the higher ones. This course occupies 5 hours weekly through two terms, and is required of scientific students in the freshman year, but is elective to classical students, and those in the Latin scientific course in the junior year.

A course in botany, with special reference to morphology and physiology of the phanerogams and higher cryptogams is given, occupying 5 hours weekly during one term. This course is required in the freshman year of students in the scientific and Latin scientific courses, and is elective to students following the classical and Greek scientific courses in either the sophomore or junior years.

The course in zoölogy is a general one, devoted to the morphology and physiology of typical animals with particular attention to their development. This course occupies 3 hours weekly during one term and may be chosen by all students in either the junior or senior classes.

The course in physiology is mainly confined to human physiology, although considerable comparative work is done. It occupies 5 hours weekly during one term, and is required of all students in either the sophomore or junior year.

In addition to these there are conducted "honor courses" under the direction of the instructor, but with no class work. The subjects assigned are as follows:

Freshmen.—The physiological anatomy of some plant or animal.

Sophomores.—Plant histology.

Juniors.—Human and comparative histology.

Seniors.—Experimental work on digestion or on the functions of nerves.

The biological department now occupies four rooms, and others may be fitted up as special laboratories as occasion requires. All needful apparatus is provided to accommodate thirty students working at a time, and this work is required of all students. Facilities are provided for work in histology and embryology, and there is also a considerable collection of physiological apparatus.

The zoölogical museum was established in 1890, and is especially rich in South American birds and mammals. It also contains numerous specimens of cœlenterates, echinoderms, and mollusca, together with a collection of skeletons illustrating all the classes of vertebrates and nearly all the orders of mammals.

UNIVERSITY OF SOUTH CAROLINA.

COLUMBIA, S. C.

In the three courses leading to the degree bachelor of arts, botany and physiology are presented in the sophomore year, with biology and physiology as electives in the junior. In the six courses leading to the degree bachelor of science the biological work varies. In the general-science course structural botany and physiology are considered during two terms of the junior year, the time being equally divided. Zoölogy is elective during the same period. In the agricultural course structural and systematic botany are considered, each during one term of the sophomore year, while zoölogy and physiology receive the same time in the junior. In the course in chemistry attention is given to zoölogy, physiology, structural and systematic botany, each occupying one term of the junior year, while microscopy and bacteriology are presented in the senior year. The biological work of the course in natural history is the same as that just mentioned, with the addition of entomology during one term of the senior year. In all of the courses mentioned 3 hours weekly are

devoted to class work, consisting principally of lectures, accompanied in most cases by practical work.

The course in structural botany consists mainly of lectures upon the general morphological characters of higher plants, with a discussion of those points which indicate relationship, together with the examination of specimens in the class room. In systematic botany most of the time is given to practical work in the examination and dissection of plants, written descriptions being required. The course in general zoölogy is devoted largely to the leading facts of zoölogical science, the laws of development, heredity, variation, correlation, etc. As occasion permits, the regular class hour is devoted to practical work in the study of animals. The course in entomology, specially designed for agricultural students, consists of lectures upon the life histories of insects and upon the characteristics of those families most important in relation to agriculture. In connection with this extra laboratory work is required. The physiology course consists of lectures and demonstrations, while the work in bacteriology is entirely done in the laboratory.

In all of the departments mentioned post-graduate courses are offered. In botany the student may select for special study one of the orders of phanerogams or cryptogams or devote attention to the embryology of plants. Parasitic fungi may also be selected for study. In zoölogy the student may choose morphological or physiological work devoted to any class of animals.

The laboratory is supplied with compound microscopes, reagents, aquaria, culture apparatus, etc.

For admission to the undergraduate courses no requirements in science are made in any department.

UNIVERSITY OF TENNESSEE.

KNOXVILLE, TENN.

The biological work of this institution is begun in the sophomore year of the scientific and agricultural courses. Physiology occupies 5 hours weekly during the first term, while during the second, botany occupies 3 hours and general zoölogy 2 hours weekly. All of these courses are introductory in character. The course in physiology is given largely for the sake of the information involved and its bearing upon personal hygiene. The botanical work includes a study of phanerogams, with the relations of species and the preparation of a herbarium. The zoölogical course is a general one, intended to be complete in itself for those who carry their studies no further. Students who expect to prosecute more advanced studies in biology will take, in the second term of their sophomore year, a course in zoölogical methods, in which the time is divided equally between histology and entomology, the latter being selected as an introduction to systematic zoölogy.

Beginning with the junior year the biological work is elective (with

one exception later mentioned). The botanical course offered in the junior year consists mainly of practical work. The first term is devoted to structural botany and histology, after which the subject of economic botany and vegetable pathology receive attention. In zoölogy the same general method is followed, a minimum of 3 hours being devoted to laboratory work, with occasional lectures in addition. The practical work is mainly systematic work, while lectures are delivered on the structural features of animal groups. Further courses of a more special nature are also offered. A course in entomology, occupying 3 hours weekly, is required of juniors in the agricultural course. Courses in human physiology and histology are offered to students who have completed the work of the sophomore and junior years. These are intended primarily for students intending to follow a medical course. Individual courses are also planned for those qualified to pursue them.

Separate laboratories are used for work in botany, zoology, and physiology. Each of these is appropriately fitted with all the apparatus needed in the work ordinarily done. For purposes of illustration the university possesses large herbaria, and zoölogical specimens in sufficient abundance to illustrate the courses given. The collection of insects is specially valuable.

For admission to the freshman class no knowledge of science is required. The preparatory schools of the State furnish very meager courses in scientific branches, and give no training in independent seeing and thinking.

UNIVERSITY OF VERMONT.

BURLINGTON, VT.

In the classical course botany is taken up in the third term of the sophomore year, and 3 hours weekly are devoted to the subject. During the first term of the junior year zoölogy is elective, the course consisting of two lectures weekly. In the second term a course in physiology, consisting of four weekly exercises, is required, while in the third an additional course in botany is elective. During the junior and senior years a course in general biology is offered as an elective study. This consists of a series of lectures accompanied by laboratory work. During the two years about fifty lectures are delivered, while the student may spend from 4 to 12 hours weekly in laboratory work.

In the agricultural course physiology occupies the second term of the freshman year, while in the third the anatomy of domestic animals is taken up. General zoölogy is introduced in the first term of the junior year, while botany follows in the third. The breeding of animals is first considered in the first term of the senior year, entomology being taken up in the third.

In all the work mentioned practical methods have a prominent place. The work in botany is designed to impart a scientific knowledge of both vegetable structure and physiology, and is based upon as large an

acquaintance with the plants themselves as can be gained in the time allotted to the subject. Special attention is given to the flora of Vermont, and written descriptions of many of them are required. In connection with the course in zoölogy each student is required to dissect at least one representative of each of the great groups of the animal kingdom, and prepare a written report upon his work. Special attention is given to the groups of insects injurious to agriculture.

All of these courses are conducted by lectures except the course in physiology. Laboratory work is required of all students taking biological courses, the amount of time devoted to it differing in different cases. The laboratory consists of several rooms equipped with microscopes and other necessary pieces of apparatus. The museum contains nearly all the mammals of Vermont, together with numerous foreign specimens, several hundred specimens of birds and numerous skeletons and skulls. It also contains a considerable number of invertebrate specimens, and glass models of delicate marine forms. As illustrating the course in botany, the museum contains several hundred specimens of wood and a herbarium.

UNIVERSITY OF VIRGINIA.

CHARLOTTESVILLE, VA.

The chair of biology exists here upon an agricultural foundation, in consequence of which two courses in biology are offered, one for the benefit of those following agricultural pursuits, and the other for those wishing to become teachers of biology, or wishing some knowledge of the science as a part of a general education. Each course occupies 2 years, the work of the first year being the same in both. This consists of a course in general biology, designed to make known the fundamental facts and laws of plant and animal life by means of a practical study of representative forms. The study of animal and vegetable forms is pursued separately, but in parallel courses, 2 hours weekly with accompanying laboratory work being given to the former and 1 to the latter subject.

The agricultural course occupying the second year is devoted to the consideration and practical study of selected topics in economic botany, such as the physiology or diseases of plants, or the natural history of cultivated varieties, etc.; in economic zoölogy, as the life histories of insects, parasites, the anatomy and physiology of domestic animals; and in agriculture, as the growth and nutrition of crops, soil drainage, rotation of crops, and other subjects connected with the theory and practice of agriculture. In the general course in biology the second year is devoted to lectures and practical work in the anatomy, histology, and embryology of vertebrates.

Students who have completed the class work as indicated above may undertake the solution of original problems of practical or scientific interest under the guidance of the professor.

The laboratory is provided with the apparatus necessary in the study of the gross and minute anatomy of animal and vegetable forms, as well as with a complete photographic outfit. The museum contains large collections of mounted skeletons, stuffed animals, plaster models, etc. There is also a large herbarium containing specimens representing the flora of all parts of the world, and in addition numerous charts, papier-maché models of flowers and fruits, sections of wood, etc.

In the University of Virginia the system of independent schools prevails. No entrance examinations are held, and there are no prescribed curricula leading to any of the degrees. The courses in biology are therefore open to any who may desire to follow them, and at any time.

UNIVERSITY OF WISCONSIN.

MADISON, WIS.

The requirements for admission to the classical courses include no scientific subjects. Students entering the general scientific course are expected to have an elementary knowledge of physics, physiology, and botany. It is highly recommended, though not required, that laboratory work be done in connection with each of these courses. A large number of high schools and academies (about eighty in all) are classed as accredited schools, and students graduating from them are admitted to the freshman class without examination.

Several different courses of study are provided, in which the work in biology differs considerably, as below stated. In the ancient and modern classical courses the sciences are all elective, and at any time subsequent to the beginning of the sophomore year either physiology, botany, or zoölogy may be chosen. The course in physiology open to sophomores consists of three recitations weekly during two terms, with no laboratory work. The course in botany begins with a study of general vegetable morphology. In this the student is first made acquainted with the fundamental phenomena of living organisms as illustrated by the plant cell, and then proceeds to the study of the life histories of representative plants leading up to the flowering plants. To this work two lectures weekly and 8 hours' laboratory work are devoted. The work in zoölogy occupies two recitations weekly during two terms, and the student may take in addition 8 hours' laboratory work weekly.

During the junior and senior years the work is chiefly elective. Certain subjects, among which are elementary botany and zoölogy, are required of all students before graduation. The remaining courses offered in the departments of zoölogy and botany may all be elected by students in their junior and senior years, it being left to the student to decide whether he will elect one or more leading courses and pursue them continuously with a view to thoroughness and mastery, or distribute his studies more widely with a view to general information and

well-balanced development. The courses in zoölogy open to such students are, a general course in the morphology and classification of invertebrates, special groups being taken for detailed treatment, and the entire course occupying 1 year; a similar course in the study of vertebrates, occupying 12 hours for laboratory work and two lectures weekly during two terms; a course in embryology, consisting of three lectures and 10 hours' laboratory work weekly during one term. This is devoted to the development of the chick. Students who have completed the above work will be given facilities for special advanced work along any line which they may desire. The courses in botany open to juniors and seniors are, a course in general vegetable morphology, occupying 10 hours weekly during two terms, which continues and supplements the work of the sophomore year; a course in vegetable histology, occupying the same amount of time, in which the tissues of phanerogams and ferns are studied; a course in embryology and physiology, occupying 10 hours weekly through the year; a course in pharmaceutical botany, occupying two terms and designed to give students such familiarity with plants as to enable them to pursue profitably their studies in pharmacognosy. In connection with this a herbarium of 25 specimens must be presented. Students who have completed all the courses offered may take up some special problem for solution, devoting to it 15 to 20 hours weekly, and supplementing the work by reading. A thesis based on this study is required.

The statements above made apply with equal force to the ancient and modern classical courses and the English course. In the general science course botany and zoölogy are required in the freshman year, each occupying 5 hours weekly during two terms, and the course being the same as an elective in the sophomore year of the classical course. During the sophomore year three full electives are required, and botany and zoölogy may be chosen, the course being any of those enumerated as junior electives in the classical course. During the junior and senior years three full scientific studies must be taken, either zoölogy or botany being required. The courses to be pursued may be any of those previously mentioned.

A special scientific course, leading to the degree B. S., may be taken by those intending to pursue the study of medicine. In this the requirements are the same as in the general scientific course, but the electives are mainly chosen from the biological courses offered.

In the agricultural course the biological work is mainly selected from those courses already mentioned, the freshman year being devoted to botany, the sophomore to zoölogy, and the junior to animal and vegetable physiology. During one term of the junior year entomology is taken up, attention being given specially to injurious forms of insect life. In the senior year the work consists of the investigation of special problems in any of the departments previously studied.

Five separate laboratories are devoted to the uses of the biological

department. They occupy the third floor of the Science Hall, a building erected in 1886. The largest of these is for elementary work in botany and zoölogy. It consists of a well-lighted room, 52 by 40 feet, arranged to accommodate seventy-two students. It contains seventy compound microscopes, and, in addition, dissecting microscopes and all other apparatus needed in elementary work in great abundance. Two smaller rooms are devoted to botanical work and two to zoölogy. Of the former, one is supplied with microscopes, microtomes, water baths, and other apparatus needed for advanced work in vegetable histology, while the other contains a clinostat, auxanometer, spectroscope, thermometers, and other apparatus suited for physiological work. Of the zoölogical laboratories, one is devoted to histology and bacteriology, and is supplied with all the apparatus, including culture and sterilizing ovens, needed in such work. The anatomical laboratory is supplied with all conveniences for dissecting, and contains numerous skeletons, also wax models, illustrating the development of various vertebrates.

UNIVERSITY OF WOOSTER.

WOOSTER, OHIO.

Botany, physiology, and physical geography are required for admission to the freshman class and in the preparatory course, provided these subjects are taught. Two hours weekly are given to each subject and additional time is devoted to experiments and demonstrations in physiology and to practice in plant analysis.

The biological work in the college course begins in the second half of the sophomore year, when a course is given in general biology, followed by alternating elective courses, open each year to members of either the junior or senior classes. The character of work is determined in part by the needs and inclinations of the class, being devoted during 1890-91 to vertebrate morphology and physiology. In both of these courses 2 hours weekly are devoted to lectures and recitations, and there are in the sophomore year 2 hours of laboratory work required. In connection with the elective courses 4 hours are prescribed. The only text-books used are laboratory guides, supplemented by a reference library kept in the laboratory.

Laboratory accommodations are provided for twenty-four students. The work-room contains separate tables for that number, each equipped with a complete outfit of microscopes and dissecting instruments, while the store-room contains a supply of reagents, glassware, and special apparatus. A separate room is provided for aquaria, and abundant provisions are made for keeping animals and plants alive for study. With reference to laboratory management Professor Mateer writes:

I have all tables and stools fastened to the floor, and have just two rules; 1. No unnecessary leaving of seats. 2. No talking above undertone. I enforce these and the result is good order and good work.

VANDERBILT UNIVERSITY.

NASHVILLE, TENN.

For admission to the freshman class no requirements in science are made. In the courses in arts and letters the prescribed work in biology begins in the senior year, preceded by chemistry and physics in the junior. The subjects of botany and zoölogy are presented in the first half of the senior year. In the scientific course the same work is prescribed for the sophomore class, preceded by chemistry in the freshman year. During the second half of the junior year in this course laboratory work along the same line is provided.

Candidates for the master's or doctor's degree must follow more advanced courses of instruction, supplemented in the latter case by original investigation.

The department of natural history and geology occupies one floor of the Science Hall, having a museum, laboratory, and lecture room. The museum is of considerable size and the laboratory equipped with adequate apparatus.

WABASH COLLEGE.

CRAWFORDSVILLE, IND.

The requirements for admission to the freshman class include no scientific subjects. In the three courses leading to the degrees bachelor of arts, bachelor of science, and civil engineer the biological work offered is nearly the same. In the two last named courses the work begins in the freshman year with a course in human physiology, occupying 4 hours weekly during one term. From this point the work of all courses is partly required and partly elective.

The course in botany begins in the sophomore year and occupies the second and third terms. All students are required to follow this course. Lectures are given upon general botany, and from 4 to 6 hours weekly are spent in laboratory work. This work consists first in the dissection and examination of floral structures, leading to work in systematic botany, in which the local flora is made the basis of minute study. Botany is elective to students of all courses in the junior and senior years, and consists mainly of laboratory work, with occasional lectures. The junior year is devoted to a study of the anatomical and reproductive characters of plant types, taken in the order of their increasing complexity, the student being thus enabled to trace for himself the evolution of the vegetable kingdom and acquire that comprehensive knowledge of it that can be gotten only by such study. The work of the senior year is more special in character, consisting of the solution of problems in either structural, systematic, or physiological botany.

Zoölogy is required of sophomores in the scientific courses, and occupies two terms, one being devoted to the invertebrates, the other to the

vertebrates, with three weekly exercises in each. Special emphasis is laid upon the dissection of various animal types selected from the entire range of the animal kingdom. The work of the junior and senior years is elective, and may be adapted to meet special needs.

Human physiology is required of juniors in all courses during two terms.

The Hovey Museum furnishes the necessary lecture rooms, laboratories, and museum rooms for the department. The rooms and their equipment are abundant for the demands made upon them, and special provisions for advanced work in botany and zoölogy have been made.

The herbarium contains nearly 50,000 specimens, fully catalogued and arranged. The North American species are fully represented, in many cases by type specimens. Numerous representatives of the flora of all parts of the world are also included. In addition to these there are about 700 trays of specimens illustrative of economic botany, including most of the useful products obtained from plants.

The zoölogical collection contains a considerable number of vertebrate skeletons and stuffed specimens, but is especially rich in invertebrates, particularly corals and marine shells. All of the classes of invertebrates are represented with sufficient fullness to make this collection one of great value for purposes of teaching or research.

WAKE FOREST COLLEGE.

WAKE FOREST, N. C.

The class system is not followed here, but any study may be elected at any time by one who is properly prepared. The entire course occupies about 1½ years, and is usually taken by students in the third and fourth years of their course. Structural and systematic zoölogy form the introductory subject, and this alone is required of students applying for the degree of bachelor of arts. This course occupies 4 hours weekly during one half-year, with three periods additional devoted to laboratory work.

Students applying for the degree of master of arts are required to complete courses in physiology and botany. In the former, three weekly exercises are conducted, with occasionally an additional hour for laboratory work. The botanical course occupies 3 hours weekly, with the same amount of time devoted to practical work. About one-half of the time is given to the flowering plants, and the other half is divided between vegetable physiology and histology and cryptogamic botany.

Special courses are planned for those displaying a marked aptitude for such work, and these are of the nature of original investigation but are confined to fields already explored.

The laboratory is equipped with microscopes and the usual accessories. A small museum containing representatives of most of the groups of animals is available for illustration.

WASHINGTON AND JEFFERSON COLLEGE.

WASHINGTON, PA.

Students are admitted to the freshman class without any knowledge of science.

Students of the scientific course begin their work in the freshman year with a course in structural and systematic botany occupying 3 hours weekly during two terms. During the sophomore year practical biology, comparative anatomy, and cryptogamic botany are considered in turn, 3 hours weekly during one term being devoted to each. The course followed by scientific students concludes with a course in physiology, occupying 2 hours weekly during one term of the junior year. This course is also taken by classical students, and constitutes their first work in biology. Following this, in the second and third terms of the junior year, are courses in zoölogy and botany, to which the same time is given.

The laboratory is arranged for work in geology as well as biology, and contains facilities for elementary work. The zoölogical museum contains a representative of nearly all the orders of marine invertebrates.

WASHINGTON AND LEE UNIVERSITY.

LEXINGTON, VA.

The courses leading to degrees are not rigidly fixed, but any study may be elected by the student at any period in his course.

Three separate courses in biology may be elected. One of these, occupying 3 hours weekly through the year, is devoted to comparative zoölogy and phænogamic botany. In connection with the latter subject, plant analysis is practically studied. A course in practical biology is also given. In this, at least 4 hours weekly are devoted to the practical study of animal and vegetable forms, selected to show the leading modifications of structure found in the animal and vegetable kingdoms.

The Lewis Brooks Museum contains numerous specimens of interest and value in illustrating the course. The zoölogical specimens are mainly vertebrates, but include numerous representatives of all the classes. The botanical collections include a herbarium of about 5,000 specimens of European plants, a considerable collection of wood samples, besides numerous models and charts.

WESLEYAN UNIVERSITY.

MIDDLETOWN, CONN.

The requirements for entrance to the classical and scientific departments include no scientific subjects.

The work in biology begins with a course in botany, which occupies 5 hours a fortnight during the second and third terms. This is required

of freshmen in the scientific course, and elective to classical sophomores. The work consists of text-book exercises, supplemented by lectures and practical work. During the latter part of the course there is practical work only.

A course in physiology, occupying 3 hours weekly during the first term and 2 during the second, is required of scientific sophomores and classical juniors. In this course instruction is given mainly by lectures, accompanied by demonstrations. The course aims at giving the student a general knowledge of the functions of the various organs of the body under normal conditions.

A course in zoölogy, elective to classical juniors and scientific sophomores, is given, occupying 5 hours fortnightly during the year. In this course attention is paid to the broad features and general laws governing living things, rather than systematic work. A number of animal forms are studied, both in relation to their adult form and development.

A laboratory course in practical biology is offered to a limited number of students who are properly qualified. This course may be varied very widely to suit individual cases. Special attention may be paid to physiology, histology, and mammalian dissection, as is recommended for medical students, or a more general course may be followed. A course occupying 2 years is planned, consisting in the examination of typical members of the animal and vegetable kingdoms. The second year of this course is devoted to experimental physiology, and to histology, bacteriology, embryology, and mammalian anatomy. In this work at least 13 hours a fortnight are necessary.

The laboratory is at present capable of accommodating about fifteen students, and is equipped with microscopes and other apparatus necessary in elementary work. It contains also apparatus necessary for investigations upon bacteria. A considerable quantity of apparatus for advanced physiological work has recently been ordered, and it is intended to increase the laboratory accommodations accordingly, as well as add to the courses mentioned above a special course in experimental physiology.

The museum of natural history contains considerable botanical and zoölogical collections. The herbarium contains about 10,600 plants, while there are in addition 300 specimens of wood and 600 miscellaneous specimens. It includes nearly the entire flora of New England, as well as many specimens from other localities. The zoölogical collections number about 13,000 species. It is especially rich in the vertebrates of North America, the marine invertebrates of New England, and the mollusks generally, containing of the latter class 90,000 shells and 4,000 preserved specimens.

WEST VIRGINIA UNIVERSITY.

MORGANTOWN, W. VA.

The regular course of instruction in biology begins in the third year, though special students if qualified may begin in the first year. Botany and chemistry are required for entrance to the freshman class, and also required of special students wishing to prosecute biological studies. Zoölogy occupies two terms, and attention is mainly given to the vertebrates. Each student is required to prepare the skeletons of 5 vertebrate types, and make a general study of their internal organs and systematic relations. Each student is also required to take a course in histology occupying about 6 weeks. Training is given in methods, and the student then proceeds to the examination of tissues, lectures being previously given upon the tissues under consideration.

Structural botany is considered during two terms, and is entirely practical work. The various tissues of higher plants are made the objects of study, after which bacteria are taken up.

Human anatomy runs through the entire second year, the course consisting of five weekly lectures. Students are required to dissect an entire human body. Students studying for a degree in science or arts are exempt from the practical work.

No laboratory equipment is provided by the university, students being required to furnish their own microscopes and outfits.

WILLIAMS COLLEGE.

WILLIAMSTOWN, MASS.

For admission to the freshman class no knowledge of science is required.

Biology is taken up in the second term of the sophomore year and continues to the end of the year. This course, which is required of all students, consists of elementary biology with zoölogy and botany. In connection with this no practical work is required save exercises in plant analysis.

In the junior and senior years nearly all of the scientific courses are elective. The junior course comprises a study of plants and animals from a physiological as well as anatomical standpoint, text-books being used in part. In this work the higher and better known forms are first taken up, after which the more primitive forms are considered. Systematic work forms a part of the course, but the primary aim is to bring the student into direct contact with nature. In the senior year comparative zoölogy is continued. A practical study is made of the embryology of birds and amphibia, and a course is also given in animal histology. Short lecture courses are also given on topics of general interest. Further instruction of a more advanced nature is given to stu-

dents who are properly qualified along the lines indicated by the elective courses. As an aid in this work, an association of students is formed for the reading and discussion of current journals. In this connection the "Lyceum of Natural History" should be mentioned. For 50 years past this has in various ways promoted the study of natural history, more especially by forming expeditions to regions of scientific interest.

A room 60 by 35 feet has recently been equipped as a biological laboratory. It is conveniently arranged, well lighted and heated, and supplied with microscopes, microtomes, incubators, aquaria, etc. Six hours weekly are spent in laboratory work by students taking the elective courses, while those doing the advanced work spend as much time as the work may require. A special fund has been provided for a scientific expedition every fourth year. Arrangements have also been made by which one table at the marine biological laboratory is open to students who are properly qualified.

YALE UNIVERSITY.

NEW HAVEN, CONN.

The requirements for admission to the freshman class include no knowledge of science. As the courses are at present arranged, no scientific subjects are begun until the junior year. To supplement this it is strongly recommended that students should include in their preparation for college some of the natural sciences and chemistry.

In the junior and senior years all the scientific courses are elective. A course in physiology, occupying 1 hour weekly through the year, is given to juniors, and during the second term of this year a course in botany is conducted, occupying 2 hours weekly. To students who have completed the work in physiology, as well as an experimental course in chemistry, there is open a course in comparative anatomy and histology, occupying one term of the senior year. This consists of practical work only, to which a minimum of 8 hours per week is given. The time is devoted to microscopic work and dissecting, with special reference to the rudiments of biology and the morphology of animal tissues. Seniors, who so desire, may follow two advanced courses. One of these, open only to a small number who have taken the course in botany, is devoted to the microscopic study of vegetable tissues, with special reference to ferns and mosses. This occupies 2 hours weekly during the first term. As a continuation of the course in comparative anatomy, a course is also open to seniors in physiological chemistry. This consists of practical work devoted to the study of various animal tissues, the chemistry of digestion, nutrition, etc.

In the Sheffield Scientific School several courses are offered leading to the degree of bachelor of science. Two of these may be described in detail, one being a general natural-history course, while the other is preparatory to medicine. In both of these the work of the freshman

and sophomore classes is the same, physics and chemistry being required. The studies peculiar to these courses begin in the junior year, botany being first taken up. In both courses this continues through the senior year, occupying from 2 to 6 hours weekly. Systematic botany is first considered, the object being to train students in manipulation and to enable them to recognize the chief natural orders, as well as determine the more common species. The botanical work of the senior year is entirely practical, and consists at first of a microscopic study of vegetable tissues and floral organs, after which attention is given to lower groups, as ferns, mosses, and algæ. Those who wish to carry their studies further may pursue advanced courses devoted to special groups of plants.

In the second term of the junior year of both courses embryology is presented, while in the preliminary medical course comparative anatomy and histology are studied. There are 18 hours laboratory work and one lecture weekly in this course. The special object sought in this course is the manual and mental training of the student in the methods of investigation by which the facts and principles of these sciences have been established. The work consists mainly of microscopic work and dissecting.

In the natural-history course zoölogy is taken up in the second term of the junior year and continued through the senior. In this from 6 to 12 hours are devoted to laboratory work, while during about half the senior year there are two weekly lectures. The laboratory work includes dissecting and microscopic study, as well as systematic work in zoölogy.

In the senior year of the preliminary medical course there is a shorter course in zoölogy, consisting of two lectures weekly, and there is in addition a course in physiological chemistry. This course extends through the senior year, and consists mainly of laboratory work. In it attention is first devoted to the albuminous bodies and the composition of the various tissues of the body. The detection of poisons and their action upon the tissues of the body is also considered.

The Sheffield Scientific School also offers facilities for post-graduate study in the departments of botany, zoölogy, comparative anatomy, and physiological chemistry. None of these are rigidly fixed, but may be suited to the individual needs and wishes of the student.

Separate laboratories are provided for each of these departments, and each is fully equipped.

The Peabody Museum of Natural History contains, in addition to large numbers of fossils, a zoölogical collection of large size and great value. It contains all the vertebrates found in New England, a large number of vertebrate skeletons, and in addition extensive collections of marine forms from the highest to the lowest. The marine invertebrates of the New England coast are nearly all represented, and there are also many special collections from various parts of the world.

No course in biology is offered in the following-named institutions:

Emory College, Oxford, Ga.
Georgetown College, Washington, D. C.
Gonzaga College, Washington, D. C.
Hampden Sidney College, Hampden Sidney, Va.
Mercer University, Macon, Ga.
Mount St. Marys College, Emmitsburg, Md.
Richmond College, Richmond, Va.
St. Benedict's College, Atchison, Kans.
St. Charles College, Ellicott City, Md.
St. Ignatius College, Chicago, Ill.
St. Xavier College, Cincinnati, Ohio.
Santa Clara College, Santa Clara, Cal.
Spring Hill College, Mobile, Ala.
University of Alabama, University, Ala.
University of New Mexico, Santa Fé, N. Mex.

CHAPTER III.

THE EDUCATIONAL VALUE OF BIOLOGICAL STUDIES—SCHOOL WORK.

The courses offered by the various institutions of the country show a wide diversity, so far as biological work is concerned. Whether this is owing to a lack of unanimity regarding the educational value of the different branches of biology, or is simply a matter of convenience or necessity, does not always seem evident. Certain it is, however, that present ideas of education differ in many important points from those of even a few decades ago. The distinction between education and information has never been more thoroughly appreciated than at present, as is made evident by the fact that the time-honored "culture" course which turned out men possessed of a faint knowledge of many subjects and a thorough understanding of none, which gave the observational powers no training and only practiced the reasoning powers upon imaginary premises, has almost ceased to exist. In its place we find a strong tendency to reduce the number of required subjects in the arts course and increase the extent and thoroughness of each. Although many of our colleges still retain traces of the old methods, to the extent of subordinating scientific work and doing the little that is done by methods decidedly open to question, those teachers whose opinions are most worthy of confidence agree that the value of work in any branch of natural science depends principally upon the training which the student receives in observation and in the methods of inductive rather than deductive reasoning. The training furnished by mathematics in the methods of deduction seems to be abundantly sufficient, and to render it desirable that inductive methods should be pushed to the front in other sciences as far as possible. Professor Huxley has thus expressed himself: "The great peculiarity of scientific training, that in virtue of which it can not be replaced by any other discipline whatsoever, is this bringing of the mind directly into contact with fact, and practicing the intellect in the completest form of induction." The subsequent experience of leading teachers has been such as to confirm them in the belief not only that the above is strictly true, but further, that there is no one branch of science from which all of the benefits of scientific study may be more readily realized than biology. No other branch has a greater value in training a student in independent methods of

thought, and in teaching him caution in drawing conclusions; nothing has a more decided tendency to make one truthful, confident, and self-reliant.

If we endeavor to decide how far this is appreciated and carried out in our own institutions, we find many in which it seems not to be recognized at all. If we take a number of the most progressive as a standard, it appears that a considerable proportion of our colleges are sadly behind the age, both as regards the natural order of studies and the methods by which they are presented. In many instances the order of study pursued makes it appear evident that there is no central idea underlying the course, and in more than one letter received by the writer has the statement been made that the biological course is arranged without any regard to logical order or any reference to its relation to other sciences.

The present period is largely a formative one. The agitation now going on in regard to science teaching has begun at the top and worked its way downward. Something has resulted from the adjustment of college work to university work, the establishment of more definite ideas in regard to the sphere of each and the amount of preparation necessary for the work of the university. Most of the improvement made by the smaller colleges has been due to the example of the larger ones, but, as will be evident farther on, the smaller colleges are as yet by no means fully aroused. Many facts go to show that this is rarely due to a lack of appreciation of the value of biological training, but simply because the colleges are not able to put into practice what they wish. They stand convinced, but are not able to act upon their convictions.

We must likewise look to the colleges to influence the biological teaching in the schools. While this is a matter that frequently presents great difficulties in the execution, it is still true that in the large majority of cases, the schools will teach little more of any science than the colleges require for entrance. So long as the colleges are in their present condition it is hardly fair to expect that they will exert any great influence over the schools. And yet there is one fact which has an important bearing here. In a large number of States having several colleges, most of them may be meagerly equipped, but usually there is one (commonly the State university) that is strong. This one, drawing its students from all sections of its own State at least, can, through its entrance requirements, largely influence, if not, indeed, absolutely control the scientific work done by the schools.

ENTRANCE REQUIREMENTS IN SCIENCE.

Referring to tables 2 and 3, it will be seen that in a representative number of colleges about half require some knowledge of science for admission to the classical course, while a slightly larger number require science for admission to scientific courses.

The exact numbers as well as the subject required may be seen in the accompanying table:

Studies required.	A. B. course (45 colleges).	B. S. course (42 colleges).
Science	21	25
Physiology	18	18
Physics	16	18
Botany	4	10
Zoölogy	2	5
Chemistry	3	5
Physical geography	7	10

From the great predominance of biological subjects one would naturally infer that there existed on the part of the colleges a strong belief in the value of biology as a means of preventing the formation of habits of book cramming and reciting by rote, and leading the way most easily to higher work in science. Teachers generally will recognize as desirable that the first instruction in science that a student receives should be in a branch in which he can pass from the known to the unknown by easy stages, not being overwhelmed by a mass of new matter and yet not having the way made too smooth. He should not be exposed to difficulties of too serious a nature for him to extricate himself from with a little judicious guidance, and yet he should be given tasks of sufficient magnitude to call forth all his powers in their solution. The subject should also be one in which observational methods have a prominent place, both because the observational powers first develop, and because they must be trained before one can experiment with precision.

Judged by these standards, the prominent place given to physiology is difficult to explain. Taught by the more purely inductive methods, a knowledge of the functions of the body should be based upon observations and experiments made by the student himself. He should be guided rather than led to his conclusions, and should be himself encouraged to test their correctness and trust his own results rather than any authority.

It may, of course, be questioned how free a use of inductive methods is conducive to the best results. Certainly a little done well is worth vastly more than a great deal done poorly, and yet, in any science, such as physiology, in which a certain amount of ground must be gone over to secure completeness of treatment, it is frequently difficult to get the time which this sort of teaching requires. The student must therefore obtain many of his facts from his teacher or on the authority of a text-book. One of the great objections to physiology as an introductory subject is that it is almost entirely experimental, very little being learned from observation alone. The experiments, too, are of a character unsuited to beginners. They usually require more or less expensive apparatus, and frequently involve work upon living animals, hence can not be intrusted to students, but must be demonstrated. The technical difficulties to be overcome are often very considerable, and this being evident to the student, he soon acquires the idea that the teacher is

possessed of some mysterious power, the phenomena assume a far-away character, the student is not brought into contact with nature first hand, and thereby loses in great measure the benefit which the study should yield. An additional reason against the too early introduction of physiology is the uncertain character of the experiments. Unaccountable failures may occur in any simple experiment in any branch of science, as every teacher well knows; but in physiology the danger is especially great of obtaining contradictory and misleading results, and thus failing to impress a class with the accuracy of scientific work.

A branch suitable to teach to children should be one that will stimulate inquiry, but it should be possible for the child to make many of his investigations himself. At least it is desirable that most of the questions that children are likely to ask be capable of being answered satisfactorily to them. In this much will of course depend on the skill and tact of the teacher. That perfect honesty must be exercised in dealing with children goes without saying, but it is not desirable for many reasons to have too many questions come up which the teacher must admit we can not explain. Much of this will be found to depend on the pupil's ignorance of chemistry and physics, which fact simply serves to make more evident the general principle that both of these subjects should precede physiology in the school no less than in the college. If these courses are conducted in such a manner as to furnish a real scientific discipline, many of the objections above urged against the study of physiology in schools are greatly weakened. When we consider systematic botany the case is very different. In many respects it surpasses all other scientific branches as an introductory subject. Primary teachers have found that almost without exception children will work at botany and enjoy it. Their enthusiasm is easily aroused. They will pull flowers to pieces and appreciate something of the plan upon which they are formed, using their childish inquisitiveness in prying into the why and wherefore of their structure. Something may be done, too, at a very tender age. Prof. William North Rice, in an address entitled "Science teaching in the Schools," delivered before the American Society of Naturalists, tells of a case in point. He says:

Some years ago I had the pleasure of a somewhat intimate acquaintance with a boy who, in his third summer, became very much interested in flowers. * * * Having obtained some specimens of the tawny day lily (*Hemerocallis fulva*), he noticed the long, slender bodies in the middle of the flower, and he asked his mother what they were. It seemed almost absurd to be teaching botany to a baby hardly more than 2 years old, but his mother, having large faith in the general principle that the best way to answer a child's questions is to tell the truth, told him that the things he had found were the stamens and pistil. Of course the baby did not know much about the objects which he examined. It was not time for his brain to be disturbed with matters of morphology and physiology. It was not time for him to learn that stamens and pistils are peculiarly modified leaves, or that they are respectively the male and female organs of reproduction. But his eyes were often busy that summer in looking for the stamens and pistils in various flowers, and in that simple matter of observation he succeeded quite as well as some college juniors I have seen.

This incident, together with many others which are occurring daily in the experience of primary teachers, shows that the perceptive faculties of children are apt to be greatly underestimated, for they have really attained a considerable activity at a time when the reasoning powers are in an almost embryonic condition.

Dr. Carpenter, in his evidence before the English Public Schools Commission,* said:

Any right system of education will take up the faculties in the order of their development, and it is quite certain that the observing faculties are developed before the reasoning powers. * * * The training of the observing faculties by attention to the phenomena of nature, both in physical and in natural science, seems to me to be the natural application of time at the age of, say, from 8 to 12.

The same views are embodied in the testimony of such men as Lyell, Faraday, Hooker, Owen, and others.

When systematic botany is introduced into a school course its main object is training in observation, and for that purpose it is unrivaled. Failure in observation means failure to find the name of the plant, which, instead of being the final end, serves merely as a check upon the accuracy of the work. In botany the step from known to unknown is especially easy, for in most schools it is possible to have children work upon flowers which they have themselves collected and which are to them familiar objects. In city schools, where pupils rarely see flowers growing, the case is somewhat different, and in this event it is suggested by at least one botanist of great prominence, that physics may serve better as a means of training the observing powers. The general sentiment of teachers is expressed in an article entitled, "A Plea for a Rational Education," by M. E. G. Duff.† In it he says:

I do not very much care to which of these attention is given, but probably botany is the one which it is most convenient to teach in most places. * * * If from circumstances physiology or, indeed, any study which trains the observing faculties, was more convenient than botany, I have nothing to say against it.

Systematic botany has the advantage of being entirely independent of other sciences and requiring no previous knowledge for its successful study. In this we find its great advantage for young students. But if we attempt with slightly older pupils to present the study more logically and with more completeness, and to give along with the description of the floral structures even the briefest account of their uses and functions, we at once find ourselves again dependent upon physics and chemistry. More than ever are we impressed with the fact that all science is one, for in spite of the differences in character and aims existing between the works of the schools and colleges, the necessary limitations of the former and boasted liberality of the latter, it is evident that the most humble primary-school course, if conducted in a genuine scientific spirit, illustrates the mutual dependence of all branches of

* Quoted in "Culture Demanded by Modern Life," Youmans. D. Appleton & Co. 1889.

† Fortnightly Review, N. S., vol. 22, 1877, p. 170.

science quite as fully as the most elaborate course planned by a noble university.

In many schools the difficulty of getting teachers capable of conducting scientific work is really a serious one, the reasons for which are evident. It will be seen further on that a large proportion of our colleges are really doing little more than school work in science, and there is a manifest inequality in the training in scientific and literary subjects. The average graduate from such a college is not prepared to conduct the simplest school course in botany, and yet these very colleges are, or at least ought to be, the source of the best teachers for the common schools. Such teachers as are furnished will naturally insist upon the same one-sided preparation as they have themselves had. If a demand for science teaching should arise in spite of the colleges, it can only be met by bringing teachers from elsewhere, and this is often impossible from financial considerations. We may confidently expect this state of things to be remedied in the near future as a result of the present agitation.

ORGANIZED EFFORTS TO ADVANCE SCHOOL WORK.

In 1879 a committee was appointed by the American Association for the Advancement of Science to investigate the question of science teaching in the public schools. This committee, consisting of E. L. Youmans, A. R. Grote, J. W. Powell, N. S. Shaler, and J. S. Newberry, made a report at the next meeting, from which the following extracts are taken:

Through books and teachers the pupil is filled up with information in regard to science. Its facts and principles are explained, as far as possible, and then left in the memory with his other school acquisitions. He learns the sciences much as he learns geography and history; only in a few exceptional schools is he put to any direct mental work upon the subject-matter of science, or taught to think for himself.

As thus treated the sciences have but little value in education. They fall below other studies as a means of mental cultivation. * * * They are not made the means of cultivating the observing powers, stimulating inquiry, exercising the judgment in weighing evidence, nor of forming original and independent habits of thought. * * * But it is the first requirement of the scientific method, alike in education and in research, that the mind shall exercise its activity directly upon the subject-matter of study, otherwise scientific knowledge is an illusion and a cheat. As science is commonly pursued in book descriptions, the learners can not even identify the things they read about. As remarked by Agassiz, "The pupil studies nature in the schoolroom, and when he goes out of doors he can not find her." This mode of teaching science, which is by no means confined to the public schools, has been condemned in the most unsparing manner by all eminent scientific men as a "deception," a "fraud," an "outrage upon the minds of the young," and an "impediment in education."

The American Society of Naturalists, in pursuance of its general aim to build up the methods of science teaching, appointed a committee in 1887 to draw up a plan for teaching the natural sciences, to be recommended to the schools. This committee consisted of Samuel F. Clarke,

William N. Rice, William G. Farlow, George Macloskie, and C. O. Whitman. This committee submitted a report to the society in 1888, from which a few extracts are taken:

(1) Instruction in natural science should commence in the lowest grades of the primary schools and should continue throughout the curriculum.

(2) In the lower grades the instruction should be chiefly by means of object lessons, and the aim should be to awaken and guide the curiosity of the child in regard to natural phenomena, rather than to present systematized bodies of fact and doctrine.

(3) More systematic instruction in the natural sciences should be given in the high schools.

* * * * *

(5) An elementary (but general and practical) acquaintance with some one or more departments of natural science should be required for admission to college.

In the primary schools, and in the lower grades of the grammar schools, we would recommend that the study of plants and animals should be the main part of the scientific work. The botanical instruction should commence with such simple exercises as drawing and describing different forms of leaves, and should gradually advance to the easier and more conspicuous flowers, and later to the more obscure and difficult forms of flowers, the fruits and seeds.

The zoological instruction in the lower schools should not attempt a systematic survey of the whole animal kingdom; but attention should be directed chiefly to the more familiar animals, and to those which the pupils can see alive. The common domesticated mammals should first be studied, and later the birds, the lower vertebrates, the insects, crustacea, and mollusks. While the range of zoological instruction must be limited as regards the number of forms studied, these few familiar forms should be so compared with each other as to give the pupils, very early, some conception of the main lines of biological study—morphology, physiology, taxonomy. * * * A most important feature of the scientific instruction in the lower grades should be to encourage the pupils to collect specimens of all sorts of natural objects, and to make these specimens the subject of object lessons. The curiosity of the children will thereby be rationally cultivated and guided. * * * We would recommend the introduction of exceedingly rudimentary courses in physics and chemistry in the highest grades of the grammar school.

We would recommend, as perhaps the most desirable branches of science to be included in the classical courses in the high school, and to be required for admission to college, physical geography, phænogamic botany, and human physiology. The first is suggested as tending to keep alive in the student's mind a sympathetic acquaintance with nature in its broader aspect; the second, as affording unequalled opportunities for discipline in observations; the third, as affording knowledge of the greatest practical importance.

The most recent action of this association has been to issue a circular to all the colleges of the country asking them to take steps to make some scientific subject a part of their entrance requirement. From this the following extracts are taken:

While a liberal allowance of time is devoted to scientific studies in most of the college courses, and in the English course in academies and high schools, there is generally little or no time allotted to science in the classical courses in academies and high schools, and in the schools of lower grade. Most of the students in the colleges have therefore received no training or instruction in the sciences before reaching those studies in the college course. By so many years of exclusive attention to other subjects, their powers of observation and of imagination of physical phenomena are well-nigh atrophied; and the loving interest in nature, innate in

every normal child, instead of being systematically developed, is well-nigh extinguished.

The remedy for this state of things is to be found in the introduction of elementary lessons in science at a much earlier period of the course. We believe that the study of nature should begin in the primary school, and should continue, in increasingly systematic and philosophical methods, through all grades of the educational system. We believe that, in the light of sound principles of pedagogics, a system of education must be pronounced radically defective which fails to gratify and to stimulate the curiosity of children in regard to the things about them and within them, confining them to mere abstract studies, some of which are better suited to maturer minds.

Hence we are led to make an earnest appeal to the faculties of the colleges to make some work in science form a part of the requirements for admission, being assured that in so doing they will be taking a most important step in the direction of a symmetrical and philosophical arrangement of the educational course.

The question of the particular sciences which should be required for admission is a comparatively unimportant one. In the report adopted at the meeting of the society in 1888 (a copy of which is forwarded herewith), the committee recommended the selection of phænogamic botany, human physiology, and physical geography. * * * It was, moreover, believed that the high schools and academies in general are prepared to teach these, at least as well as any other, science studies. There is, however, room for difference of opinion on the question whether other sciences, as physics, chemistry, and zoölogy, may not have equal or even superior claims, and it is not unlikely that some preparatory schools are able to afford better instruction in some other sciences than in those recommended in the report. It would probably be best for the present, especially in view of the great inequality in the resources of different preparatory schools, to allow some degree of option to the candidate in regard to the particular science or sciences in which he should be examined. The point which we consider essential is that some study of nature should be required before admission to college.

PRESENT CONDITION OF SCHOOL WORK IN BIOLOGY.

During the past 10 years some improvement has certainly been made. While it has not spread uniformly over the country, but is limited to certain favored sections, yet the chief sign of progress is the fact that in so large a number of cases State universities in which most admirable courses in science are provided, and in which great stress is laid upon correct methods, accept the science teaching of the schools and admit pupils on certificate without examination. Especially is this true of many of the Western States, notably, Michigan, Wisconsin, Iowa, Nebraska, Kansas, Dakota, Ohio, Illinois, Indiana, and Minnesota. Of the New England and Middle States it may be said that while the city schools and those under the direct influence of the colleges give adequate courses in science, this does not seem in some States to be true of the average, at least so far as may be judged from the testimony of college officers and from the fact that comparatively few of the colleges make entrance requirements in science.

In the Southern States, notably West Virginia, North and South Carolina, Kentucky, Tennessee, Georgia, Alabama, Mississippi, and Louisiana, the situation seems worst of all. From each of these come

loud complaints of the almost total lack of scientific preparation in the schools, the best doing but little, the large majority doing none.

In some of these States there are hopeful signs. The teachers of the schools are becoming aroused to their duty in this respect, and the associations of teachers devote much time at their meetings to the discussion of methods for introducing and carrying out this work. As showing the state of mind among teachers an extract may be quoted from the report of a committee to the Tennessee State Teachers' Association, adopted in 1888:

The natural sciences, properly taught, claim preëminence over all other studies as a means of training the observing faculties. In the training of the reasoning faculties, also, they stand very high. These two faculties, observation and reasoning, are the ones that especially suffer from the excessive use of text-books that prevails among poor teachers from ignorance, among good teachers because it is forced upon them by too much work. It is in the belief that it would supply these deficiencies that your committee would state—

(1) That it is desirable that the study of some one of the natural sciences be begun at the commencement of school life and carried on continually through the higher grades. * * *

(2) That until teachers are trained for the work it is better entirely to omit all so-called "scientific" study than to give mere text-book instruction. * * *

(3) That it is desirable to substitute for the superficial courses in many sciences found in most high schools a more extended, more scientific, course in one or two sciences.

CHAPTER IV.

COLLEGE COURSES.

A study of the biological courses offered by a considerable number of colleges has brought to light many facts which the attempt will be made to arrange and harmonize in the present chapter.

A review of the statements in chapter II shows that but a small number of institutions report that they have no courses in any branch of biology, and in attempting to group these we notice that nearly all are denominational colleges under the management of the Roman Catholic Church.

In considering the work of the larger colleges in which great freedom of choice is offered, it is, of course, difficult to draw any conclusions or make any sharp statements, for in most of these biology stands on the same footing with other sciences, and the selection is left to the student's own choice. It was found impracticable on this account to embody the whole of chapter II in tables that would be satisfactory, hence a number of institutions were selected in which there was little freedom of choice, and tables 2 and 3 were constructed to show the biological work prescribed in their arts and science courses.

BIOLOGICAL WORK IN PRESCRIBED COURSES.

Considering the courses leading to the degree of bachelor of arts, offered by forty-five colleges, it is seen that some branch of biology is taught by fifteen in the freshman year, by twenty-nine in the sophomore, by thirty-one in the junior, and by nineteen in the senior. With regard to the time given to biological work, we see that in thirteen institutions the course occupies the whole or a part of 1 year, in twenty it runs through 2 years, in seven it occupies 3 years, while in four it is completed in 4 years. In the freshman year the average time devoted to biology is slightly more than half the year, with from two to five exercises weekly, as shown by table. The favorite subjects are botany, zoölogy, physiology, and biology, the details of which are as follows:

	Physiology.	Zoölogy.	Botany.	Biology.	Total number of courses in each year.
Senior	2	8	2	7	19
Junior	5	18	8	13	44
Sophomore	5	7	19	4	35
Freshman	6	5	7	1	19
Total number of courses in each subject	18	38	36	25	117

From this it will be seen that the largest number of courses offered is in zoölogy, botany standing next, with biology third. The tendency to place botany in the sophomore year is very pronounced, since over 50 per cent. of the courses are there placed. It will also be noticed that 47 per cent. of the courses in zoölogy and 52 per cent. of those in biology are in the junior year. The general tendency of classical courses, where there is a prescribed curriculum, is well indicated in the above table, which shows that out of a total number of one hundred and seventeen courses about 16 per cent. is in the freshman year, 30 in the sophomore, 37 in the junior, and 16 in the senior. In thirty-four out of forty-five colleges biology is the first scientific subject taken up. In four cases it is preceded by chemistry, in three by physics and chemistry, in two by physics, in one by physical geography, and in one by geology.

Turning to consider the place which biology occupies in the science courses offered by forty-two colleges, in which most of the studies are prescribed, we find that some branch of biology is taught in the freshman year by twenty-six colleges, in the sophomore by thirty-seven, in the junior by twenty-eight, and in the senior by thirteen. The favorite subjects are the same as before, although there is somewhat less uniformity, as shown in the accompanying table:

	Senior.	Junior.	Sophomore.	Freshman.	Total.
Physiology.....	1	6	6	7	20
Zoölogy.....	1	17	12	5	35
Botany.....	1	9	27	17	54
Biology.....	8	17	7	5	37
Microscopy.....	1	1	1	1	4
Entomology.....			2		2
Morphology.....		1			1
Comparative anatomy.....	1		5		6
Embryology.....			1		1
Natural history.....			1	1	2
Total number of courses.....	13	51	62	36	162

Here botany is the subject in which the largest number of courses is given, with biology second and zoölogy third, although the distribution of subjects by classes is about as before. With regard to the number of courses placed in the different years we find that out of a total of one hundred and sixty-two courses, 22 per cent. are in the freshman year, 38 in the sophomore, 32 in the junior, and 8 in the senior, thus showing a tendency to place biology earlier in scientific than in classical courses. The average amount of time, too, is greater than in classical courses, for we find that in only four colleges is biological work limited to 1 year, in seventeen it runs through 2 years, in fifteen it is a 3-year course, while in six it is completed in 4 years. In thirty-six out of forty-two colleges biology is the first scientific subject presented. In four cases it is preceded by chemistry, and in one each by mineralogy and geology.

THE EVOLUTION OF BIOLOGICAL INSTRUCTION.

The character of the biological work at present done by our colleges can scarcely be fully appreciated without first considering something of its historical development, for the present conditions are possible only because they have largely supplanted preëxisting ones. The evolution of our present courses has resulted from the action of many forces. Some of these are internal, depending upon the conditions peculiar to each institution concerned, its available funds, the size of its faculty, the character of its students, the extent of their preparation, etc., while we also find such outside influences operating as the stimulus of competition with other colleges and the example of those prominent teachers who have now and then appeared devoting their lives to the advancement of biological teaching, raising high standards and showing by their own example how these can be put into practice.

A certain appreciation of the value of biological studies seems to have existed from an early period. At Harvard, as early as 1643, botany formed a part of the regular curriculum required of all students in the arts course. Nothing is on record, so far as known to the writer, except the fact that this course occupied 1 hour weekly during one half-year, receiving less attention than any other study except history. The name of the professor is not recorded, and it is only stated that the summer season was assigned to the "nature of plants," thus indicating that there may have been actual study of the plants themselves.*

The first series of lectures on comparative anatomy in this country was given by William Hunter at Newport, in 1754, while the first regularly appointed professor of botany is usually said to have been Adam Kuhn, a pupil of Linnæus, who was appointed in Philadelphia in 1768. Only a few names deserve special mention in connection with this early period, but among those specially prominent were Jacob Green, 1790-1841, professor at Princeton; Benjamin Smith Barton, 1766-1855, professor of natural history and botany in the University of Pennsylvania; William Dandridge Peck, who was appointed professor at Harvard in 1800; Samuel Latham Mitchill, appointed professor of natural history in Columbia College in 1792, and David Hosack, appointed professor of botany in Columbia College in 1795.

It is to these men that the country is most heavily indebted for having forced upon it some idea of the educational value of botanical and zoölogical work. To Barton especially must credit be given for arousing popular enthusiasm. It was his custom to deliver lectures of a popular character in the University of Pennsylvania, and the effect of these can hardly be overestimated. Philadelphia being the center of the early scientific research of the country, the place of resort of its

*The writer is indebted to Dr. H. B. Adams, of Johns Hopkins University, for access to a work published in 1663, entitled "New England's First Fruits," from which these statements are taken.

learned men and the birthplace of its first scientific associations, was preëminently the place from which enlarged ideas of science teaching would naturally radiate, and, coming from such a source and supported by the influences which were there effective, would attract the attention of a larger number than would have been reached in any other way.

During the early years of this century, from 1800 to about 1840, we find that most of the colleges were making some provision for at least brief courses in botany, while a smaller number made provision for work in zoölogy. But as this movement gained in extent it seemed to lose force. Few of the teachers of this early period were themselves investigators. In too many cases the medium-sized colleges seem to have blindly followed the example of those more favorably situated, but intrusted the botanical and zoölogical teaching to incompetent hands. Courses of a very incomplete nature were given which did not commend themselves, and in consequence the teaching of biology did not grow, if, indeed, it remained up to its early standard. The educational value of real work in biology seems not to have been generally recognized, for there is little evidence that the idea that biology is the actual study of living animal and vegetable forms had taken any firm hold upon teachers generally. What little the student saw of nature was in the class room, and the opportunities for making any further inquiry, if a student should so desire, were at best but meager, and in many cases totally wanting.

INFLUENCE OF AGASSIZ ON BIOLOGICAL TEACHING.

The year 1846 was an eventful one for the teaching of biology in this country, for in that year Louis Agassiz left the home of his youth in Switzerland and came to America. It is impossible to overestimate the importance of the advent of this distinguished man, and no words are too strong to do justice to what he did for biology. Of his greatness as an investigator we shall have occasion to speak later. His work as a teacher, in which he was perhaps even more illustrious, is what now concerns us.

His coming marked the beginning of a new epoch, and the seed which he sowed are still bearing a rich harvest.

In a personal letter to the writer, Prof. A. S. Packard, referring to the work of Agassiz to advance biological teaching, writes as follows:

He did an immense work in his public lectures to popularize zoölogy and geology, to dignify the subject, to show people its great importance as a means of culture and training. His reputation, eloquence, noble presence, and pleasant voice, unselfishness and devotion were at once apparent. He carried his audience with him, and awakened attention to the value of the study of science for its own sake and for the truth's sake with a success which was phenomenal.

Owing more to his influence, example, and methods than to that of any other one man, he caused the subject to be introduced not only into schools common and high, normal schools and colleges, but also into lecture courses. He also lectured to teachers, and always insisted on the value of the study. Moreover, he attracted a good

many students, who afterward became teachers and professors, all endued with his enthusiasm and methods.

His methods were to study the specimens themselves, and not simply to read about them. When I went to study with him, after graduating from college, he gave me a specimen of a dried moth, and I kept at it for a fortnight. I learned more rapidly in that time than any period since. It put me on my own feet; it taught me to use my own eyes, to depend on myself, and not depend on what others had said about it. One by this method at once becomes an original investigator, and soon able to work alone and become a critic. This was the secret of his success as a teacher; he made one at once become an investigator, and this is the secret of success in all teaching. It is now pursued in our college work in history, psychology, chemistry, etc.

The heaven worked, and Agassiz more than anyone else should be credited with the revolution in teaching: i. e., laboratory work *vs.* bookwork, or learning lessons by rote from memory. He was thus a reformer, infusing an independent spirit in his pupils. From being a study of stuffed birds and dried insects, zoölogy became a disciplinary, broadening, and philosophical study.

Also, Agassiz had great generalizing powers. His views were broad and comprehensive, and he led his pupils to take broad views. This is a very important quality of his work as a teacher.

From an address by Dr. G. B. Emerson, delivered before the Boston Society of Natural History shortly after Agassiz's death, the following passages are taken:*

In 1855, with the aid of Mrs. Agassiz, who, from the beginning, did a great deal of the work, Mr. Agassiz opened a school for young ladies. For this he was in all respects admirably well qualified. The charm of his manner, his perfect simplicity, sincerity, and warm-heartedness, attracted every pupil and won her respect, love, and admiration. He knew, almost instinctively, what we teachers have to learn by degrees, that we can not really attract, control, and lead a child, and help to form his habits and character, without first loving him; that nothing in the world is so powerful as real, disinterested affection. He gave himself, by lectures most carefully prepared, an hour's instruction, real instruction, every day. All his pupils retain their respect and love for him, and some keep the notes they made of his talks, and read them with delight. The school was continued for 7 years with great success, attracting pupils from distant parts of the country.

One of the secrets of his success as a teacher was that he brought in nature to teach for him. The young ladies of a large school were amused at his simplicity in putting a grasshopper into the hand of each as he came into the hall; but they were filled with surprise and delight as he explained the structure of the insect before them, and a sigh of disappointment escaped from most of them when the lesson of more than an hour closed. He had opened their eyes to see the beauty of the wonderful make of one of the least of God's creatures. What a lesson was this to young women preparing to be teachers in the public schools of the Commonwealth, showing that in every field might be found objects to excite, and, well explained, to answer the questions, what, and how, and why, which children will always be asking.

He had all the elements necessary to an eloquent teacher—voice, look, and manner, that instantly attracted attention; an inexhaustible flow of language always expressive of rich thought, strong common sense, a thorough knowledge of all the subjects on which he desired to speak, a sympathy with others so strong that it became magnetic, and a feeling of the value of what he had to say, which became and created enthusiasm. He thus held the attention of his audience, not only instructing and persuading them, but converting them into interested and admiring fellow students.

* Louis Agassiz as a teacher. *Barnard's Journal of Education*, vol. 28, p. 881.

His mode of teaching, especially in his ready use of the chalk and the blackboard, was a precious lesson to teachers. He appealed at once to the eye and to the ear, thus naturally forming the habit of attention, which it is so difficult to form by the study of books. Whoever learns this lesson will soon find that it is the teacher's part to do the study, to get complete possession of what is to be taught, in any subject, and how it is to be presented, while it is the part of the pupils to listen attentively and to remember. This they will easily do, and to show that they do remember, they may be easily led to give an account in writing of what they have heard. Every lesson will thus be not only an exercise of attention and memory, but a lesson in the English language, proper instruction in which is very much needed and very much neglected. Whenever a pupil does not fully understand, the teacher will have the opportunity, while he is at the blackboard, of enlarging and making intelligible.

The work of Agassiz was done largely for the future. In his work at Harvard he came but little in contact with the great mass of students, but his mission was rather to create a sentiment, to arouse enthusiasm, and to send out a body of teachers saturated with his own methods, fully imbued with his high ideals, and thoroughly trained to put his theories and methods into practice over the country.

The influence of Prof. Asa Gray upon the teaching of botany is second only to that of Professor Agassiz. Differing from him in the fact that he came more into immediate contact with the college students than did Agassiz, his methods were the same as those of Agassiz in requiring his pupils to study nature itself, for he insisted always that botany learned from books was of little or no value. From almost the beginning of his work at Harvard in 1837 he required practical work of all students, at first limiting it to work of such a character that it could be done in the class room, but later expanding it and providing special rooms and equipment.

PRESENT STATUS OF BIOLOGICAL INSTRUCTION.

The question which has now to be solved by the colleges is, What course of study is most logical, and what will give the student the most symmetrical idea of biology as a whole, and the greatest training in independent reasoning and acquirement of truth. Many of our colleges find the answer to this in such courses as those above indicated, and continue to give courses in botany, zoölogy, etc., of varying degrees of thoroughness and completeness.

✓ In 1876 Prof. H. Newell Martin entered upon the duties of the chair of biology in the Johns Hopkins University, and one of the first innovations which he introduced was the establishment of a "general biology" course. The work of this course was planned by Professor Huxley and is contained in the "Practical Biology," in the preparation of which Professor Martin had a large share. The general design of the course, as Professor Huxley states in the preface, sprung from the conviction that "the study of living bodies is really one discipline, which is divided into zoölogy and botany simply as a matter of convenience." He further states it as his belief that "the road to a sound and thorough knowledge of zoölogy and botany lay through morphology and physiology, and

that, as in the case of all other physical sciences, so in these, sound and thorough knowledge was only to be obtained by practical work in the laboratory." These views were advocated in various essays published from 1855 on, but it was not until 1872 that Professor Huxley had any opportunity to remodel his methods of instruction in accord with his own ideas. In 1875 the first edition of the "Practical Biology" appeared, its object being, as stated in the preface, "to serve as a laboratory guide to those who are inclined to follow upon the same road. A number of common and readily obtainable plants and animals have been selected in such a manner as to exemplify the leading modifications of structure which are met with in the vegetable and animal worlds. A brief description of each is given; and the description is followed by such detailed instructions as, it is hoped, will enable the student to know, of his own knowledge, the chief facts mentioned in the account of the animal or plant. The terms used in biology will thus be represented by clear and definite images of the things to which they apply; a comprehensive and yet not vague conception of the phenomena of life will be obtained, and a firm foundation upon which to build up special knowledge will be laid."

A large number of colleges now give such a course as this, and in general the plan by which the course is conducted is much the same everywhere. The general types selected are usually about the same, and the laboratory work is generally regarded as of the highest value. In certain places, indeed, the tendency has been to diminish the number of lectures, thus causing the pupil to rely largely upon himself for all the information which he receives. In only one important respect has the character of the course as laid down by Professor Huxley been modified. Up to about 1875 it was universally the custom to teach botany as though flowering plants were alone worth considering. This was true of the colleges as well as the schools. If any cryptogamic botany was taught it invariably came after the flowers had been considered. About that time Professor Farlow began to argue that the natural order of study was from below, working upwards; that the simplest forms of life, whether animal or vegetable, should first be considered, leaving until later those forms in which the manifestations of life are complicated by accessory structures.

As opposed to this view many teachers still believe that higher plants and animals, being more common and better known, should be taken up first; that a student will reach more satisfactory results in working upon a plant or an animal that is familiar to him, even though it be somewhat intricate, than he will upon a simpler one that is unknown to him, especially if in the latter case it should be necessary to employ a new instrument of study, the microscope.

In the minds of many teachers the logical and natural method prevailed, and of course received a strong impetus from the fact that when the Practical Biology appeared it advocated the same general methods.

But this was not destined to remain long unaltered. In the hands of many teachers the method seemed to fail in the very thing it is designed primarily to accomplish, not giving the student those sharp and clear ideas of the fundamental properties of living matter that are desirable. It has been suggested that these be overcome by considering first one familiar type of the animal kingdom and one of the vegetable, after which the more primitive types may be taken up. This method, although having much in its favor, never became universal. More recently, however, the whole order of procedure has been overturned by Professor Huxley himself. In the preface to the revised edition of 1888 he states:

No doubt there is much to be said for the principle of this arrangement which leads the student from the study of simple to that of complex phenomena; but the experience of the lecture room and the laboratory taught me that, philosophical as it might be in theory, it had defects in practice.

All the simplest forms of life which are easily accessible are of very minute size, and their study involves the use of high microscopic powers. The student who begins with them is therefore not merely introduced suddenly into a region in which everything is new and strange, but he has to familiarize himself with the use of unwonted means of exploration. By taking this road the teacher (to whom the world of the microscope is so familiar that he is apt to forget its strangeness to students) sets himself against one of the soundest canons of instruction, which is to proceed from the known to the unknown, and from familiar methods of learning to those which are strange.

After 2 or 3 years' trial of the road from the simple to the complex, I became so thoroughly convinced that the way from the known to the unknown was easier for students that I reversed my course and began with such animals as a rabbit or a frog, about which everybody knows something. * * * From this starting point we proceeded further and further into the unfamiliar regions of invertebrate organization until we reached the border region between animals and plants, whence there was a natural and easy ascent to the most complicated vegetable organisms.

The effect of Professor Huxley's change of position has perhaps not yet been fully felt. As far as can be gathered from available sources of information most teachers still adhere to the original order, while in only a few cases the tendency to change is observed. In this regard so much depends upon the previous training of the student that it hardly seems probable that any one method will come to be universal until the work of the schools becomes more uniform. No one will dispute the fact that for children the method which proceeds from known to unknown is best, and so long as our college students continue to be children, so far at least as their observational powers are concerned, so long will this method be best for the colleges as well.

If we examine the character of such a course we find it in many respects opposed to the spirit of the teaching which it largely supplanted. Its most striking point is its tendency to unite subjects formerly held apart. Its aim is completeness and comprehensiveness. Physiology is joined with morphology, while the life history and embryology of each organism receive attention. Moreover, every statement is based upon the solid groundwork of experiment or observation, and the conclusions reached are thereby given a positive and lasting reality to the student.

But it is impossible to carry this method very far without invoking the aid of chemistry and physics. All through the course is the student impressed with the fact that the forces which prevail in living bodies are those which operate in the inanimate world. The student, therefore, must approach this work with some knowledge of what these forces are. Who, for example, can understand digestion without some knowledge of the character of chemical reactions, animal heat and motion without an understanding of the nature of oxidation and the doctrine of the conservation of energy, sight without optics, hearing without acoustics?

In the nature of things, then, this course, while furnishing a training to the observational powers, does more than this, and has not this training as its especial aim. It assumes that this training has gone before. The value of a general biology course as a mere training of the observational powers is open to question. Teachers are agreed generally that the observing faculties should be trained at an early age, but the reasoning powers of children are too feeble to appreciate fully a course of so philosophical a character as this and follow out the inductions that can be based upon it. Neither is college age the best time to train the observational powers, for it is found to be generally true that as the reasoning faculties develop, the perceptive become dull.

The prominent position which the Johns Hopkins University occupies as a training school for teachers has had much to do with causing a widespread recognition of the value of a general biology course, and its adoption has been most marked in institutions in which there was no biological department, or at best a feeble one, up to 15 or 20 years ago. There are still many prominent colleges in which this course does not appear to be given, but on more careful examination it will be seen that, while conservatism is shown in regard to names, in reality the same work is done. Several of our larger institutions, having two or more professors, divide the work, placing the botanical and zoölogical work in separate hands, and in these cases the "Practical Biology" is frequently used as a text-book, although the courses are nominally in botany and zoölogy. Even in institutions where this is not true the influence of this course may be felt in the great improvement in the character of work done. Botany has perhaps been influenced more than zoölogy, as is evidenced by the fact that laboratory work is much more general than formerly, and, further, that courses in cryptogamic and physiological botany are now given in colleges where attention was formerly limited to flowering plants. Teachers seem now to recognize the fact that a study of flowering plants gives but a very imperfect idea of the vegetable kingdom, and, furthermore, the value of systematic work upon flowering plants in a college course does not seem to be so strongly insisted upon as was once the case.*

* The first separate chair of cryptogamic botany established in this country, so far as can be determined, was at Harvard in 1879, when Prof. W. G. Farlow was appointed.

A strong tendency is observed to place biology, and especially the general biology course, late in the curriculum, usually in the junior year. If we look over the courses given in earlier years it is usually evident, from the length of courses and character of preparation required, that much of the work done has exactly the character of work that should be done by the schools, except that the question may well be raised whether it is, under these circumstances, as well done.

Considering the character of work which may properly follow a general biology course, it appears that in many cases there is nothing, and the general biology course forms the entire biological training which a student receives. In a small number of cases additional courses are elective, but they are generally of a special nature. Most institutions which have it will now recommend, or even insist, that if a student has but a limited time to spend upon the subject the general biology course will yield the largest return. It may, indeed, be questioned whether a student who has completed this course has not already gone as far as is consistent with the general character of college courses. In no sense can this be called a special course, but it forms the natural starting point from which special courses may proceed. Accordingly we find a few of the colleges following this with courses in physiology, botany, zoölogy, etc., with a strong tendency to make them laboratory courses alone. In some cases, indeed, the student in his senior year is put at work which has the freedom of university work. He may follow out new lines if he so desires, and especially is he apt to be assigned work of a systematic, descriptive character. In other cases histology and embryology are the favorite subjects from which special topics for advanced work are selected. In this regard so much depends upon conditions peculiar to the several institutions that for details the statements in chapter II must be consulted.

LABORATORY WORK.

The value of any course in biology, whatever be the special subject taught, is directly proportional to the amount of laboratory work that it involves. While in the larger institutions there is little to criticise in this particular, especially as regards their elective courses, the same can hardly be said of the smaller ones. Ex-President A. D. White thus expresses himself:

While it may be acknowledged that in very many of these colleges the instruction in mathematics, except the highest, and in the Greek and Latin books ordinarily read, is thoroughly good and conscientious, it is certain that there is a woeful want of proper instruction in other departments.

Only a few years ago it was a matter of some difficulty to find teachers, but that difficulty can scarcely be said to exist now. The increased attention given to biology by the larger colleges has had the effect of almost overstocking the market with men thoroughly trained in the

methods of teaching and research, and abundantly qualified to take charge of the biological work in our medium-sized institutions.

The greatest difficulty lies in the fact that teachers are commonly expected to do an unreasonable amount of work. It frequently happens as table 1 shows that they have work to do in other departments with no assistance in their own, and yet they are expected to attend to the details of laboratory management, and at the same time conduct courses that shall be comprehensive enough to compare favorably with the work of larger institutions. A further difficulty comes from the fact that the time devoted to biology, and especially to laboratory work, is too short to secure the best results. The value of laboratory work is almost universally recognized, and yet on looking over chapter II it becomes evident that in most cases the amount of time devoted to it is too small to secure any decided results. The state of things is worst in colleges having close curricula or nearly so, for, as seen in tables 2 and 3, it is usually the case that no special time is provided for laboratory work, and that the instructor can use his lecture hours at pleasure for laboratory work. In most cases 2 hours of laboratory work are substituted for one lecture hour. In a few cases even large institutions prescribe laboratory work in abundance for students following scientific courses, while classical students are allowed to obtain their knowledge of nature solely from books, without any practical work being required. Again we note a few instances in which certain lecture courses are required but laboratory work running parallel with them is left optional.

It is in institutions in which the scientific courses are largely elective that the most liberal provisions are made for laboratory work, especially during the latter part of the course, where from 4 to 6 hours weekly are devoted to laboratory work, with often three lecture hours besides. It is in some cases found that, especially in the senior class, there is an increase of time devoted to laboratory work at the expense of lectures, sometimes going so far as to omit all lectures and substitute therefor individual instruction in the laboratory.

A few institutions, indeed, seem to have more time than they are able to use to advantage, and so fail to appreciate the fact that laboratory work must be properly managed or its results will not be gotten. Some are open to the charge of paying overattention to details, allowing pupils to become absorbed in the purely mechanical part of drawing, section cutting, etc., forgetful of the real object of their work. A laboratory abused is as bad as, or worse than, none, and fully justifies the objections of those opposed to such work.

As remarked by Prof. William A. Locy: *

The natural result of the laboratory work should be to cultivate in the student a scientific attitude of mind, to give accuracy in observation and independence in forming a judgment upon what is known from personally acquired knowledge. This first-hand knowledge must, of course, be acquired from actual objects, and the more completely they are studied the better; let them be handled, observed, drawn,

* Education, 1889, page 673.

described, impressed upon the mind through as many channels of sense as possible. This direct study from the actual object is so fundamental, that I venture to repeat that it is the foundation of all good teaching in zoölogy.

The results of personal observations on the part of the student ought to be recorded in the form of drawings and written descriptions. The objects should be carefully observed before drawing is attempted, as it is essential to remove the mechanical elements as far as possible. The value of drawing, in giving directness to observation, is recognized by all teachers, and additional points of structure and relationship of parts will be noticed by the students as soon as they begin to sketch. These laboratory sketches should be viewed, not as artistic efforts, but as a means of expressing observations and conclusions in lines, and of value in proportion to the accuracy with which they represent characteristics accurately observed and intelligently interpreted. The best executed drawings, as regards foreshortening and shading, are often those of least value.

In most colleges with close curricula the attempt is made to teach too many sciences without sufficiently thorough work in any. The question of scientific methods seems to be overcome by a desire to have every student come under every teacher, unmindful of the fact that he receives a considerable amount of fragmentary information, in quantities perhaps too great for him to digest; that he receives a minimum of methods, and those are repeated. The result is that he receives but imperfect training in the use of methods and has no conception of the completeness and symmetry of any one of the subjects he has taken up. As opposed to this we find a small number of places solving the difficulty by insisting that in a course which is mainly literary in nature, one scientific study is all that should be required, but it should contain laboratory work and be so conducted as to put the pupil in full sympathy with the methods of scientific inquiry.

If laboratory work is to accomplish what is claimed for it, it is of vital importance that the classes shall not be too large. Each student must be the special study of his instructor, and the proper method of treatment for each man must be found. The personal equation and initiative power of the student must be considered with the greatest care. This is well stated in the "Handbook of Information Concerning the School of Biology" of the University of Pennsylvania:

The individuality of students should be fostered by the abolition of all marking or grading systems or anything approaching the old class system, in so far as possible. All nature condemns uniformity; natural attributes need guiding, not repressing, and the successful laboratory instructor seeks to develop common sense—a possession which nothing can replace, not even genius. He aims to stimulate originality in place of acquisition by rote or rule of thumb, and he accomplishes this most surely by an individual personal interest in each student.

The proper number of students that should come under one instructor in a laboratory is a point in regard to which there is not much difference of opinion. Professor Farlow regards it as "desirable that there should be one assistant for every twelve students in a laboratory, and necessary that there should be one for every twenty men, if the work is to be well done."*

* The Task of American Botanists. Popular Science Monthly, July, 1887.

With a larger number than this much time will be lost in a laboratory, from the fact that a singular helplessness seems generally to take possession of students, especially beginners, in laboratory work. The student, not knowing exactly what to do, has rarely the insight to find out for himself until the instructor can be consulted, and there is grave danger that students will then work together and allow one or two bright ones to do the thinking for all.

If it be true, as it doubtless is, that the best results are not generally being reached in the laboratory work conducted in a large number of our colleges, the cause is to be found mainly in two particulars—imperfect preparation and an inadequate number of teachers. In regard to the former we may quote from an article by Professor Farlow, read before the American Society of Naturalists at their meeting and published in the *Popular Science Monthly* for March, 1886: He writes:

It seems a great pity that students should come to college so ill fitted as are the majority to undertake biological work. But we must accept things as they are, and there is no use in attempting to take the second step before the first has been taken. If the schools can not or will not teach observation, then it must be taught in college, no matter if it does seem to be child's work. In colleges, however, it is absolutely impossible to find the time or the means for training everyone to become an observer, and we are obliged to distinguish between two different classes of persons in arranging courses in biology. The first and much the larger class in eastern colleges includes all those who are preparing themselves for literary, legal, and other similar pursuits, and who wish to know the most important facts about animal and plant life, but who, after they have entered college, can not afford the time to train themselves for strictly scientific studies. This class must of necessity be taught by lectures and perhaps a few demonstrations, and as far as the method is concerned it is the same as that pursued in teaching literature, history, or other subjects in which general information is sought.

The second class of students includes those who are intending to become professional naturalists, teachers of natural science, or medical practitioners; in short, all who need to know plants and animals practically and the methods of biological investigation. * * * Merely listening to lectures, however entertaining or full of information, is not enough for this class of students.

To meet this want and make biology a means of education as well as information to all students, larger teaching forces are absolutely necessary. Many institutions adopt the plan of calling in the aid of advanced students in directing the laboratory work of beginners, and the results are usually satisfactory.

In most of the books commonly used as laboratory guides, the existence of an inadequate teaching force seems to be assumed, and exceptions may be taken to many of them on the ground that their directions are too full. The organisms considered are commonly first described, and the student is then given directions for verifying the description. When this method was first introduced it was without question a wonderful advance upon the methods previously in use and caused as complete a revolution as was then possible, but it seems now to have certain objections. It does little to put the student in the attitude of an original discoverer, for it gives him few questions the answers to

which he must seek from nature. It tells him in advance what he will see, thereby increasing his confidence in printed statements and running the risk of making his reliance upon authority more absolute than ever. Moreover, the tendency to do dishonest work is, under these circumstances, often too strong for the average student to resist. He will see what he is told to see, thereby coming soon to regard the fact as the thing which he must acquire. He loses all appreciation of the training in methods and soon comes to look upon laboratory work as a useless superfluity.

While it is an invidious task to make distinctions between books, it may be allowable in this connection to refer to one—Colton's *Practical Zoölogy*—as the first conspicuous example of a laboratory guide which treats a number of types briefly and requires all of the points that are not too difficult to be made out by the pupil. Questions are frequently asked without any hint being given as to the answer. This can only be gotten from nature herself.

TEXT-BOOKS IN BIOLOGICAL TEACHING.

One of the most important results of the new methods of biological teaching is a strong feeling against "book science," but the difficulty exists of deciding upon the necessary mean between the total abandonment of books, as far at least as descriptive work is concerned, and the substitution of books for nature, which was a few years ago so common. On consulting the reports received from the institutions previously mentioned, we find that they almost unanimously state that certain text-books are used for reference, but that their main reliance is upon laboratory work, supplemented by lectures. In biology, especially descriptive botany, and zoölogy, the use of text-books is peculiarly impossible. No book constructed for one community will answer fully for another, unless the materials required are gotten from wherever they may happen to be found; but if this be done the great advantage of biology as a study of objects already familiar is in great measure lost. It is scarcely too much to say, too, that no teacher can prepare a text-book of this character that will be quite satisfactory to others; and accordingly we find that where a book is used at all it is nearly always largely supplemented by lectures and virtually remodeled to suit special needs. In no more striking manner is the prevailing state of opinion shown than by the fact that in the past 10 years very few text-books in descriptive biology have been produced, while in the same period many laboratory guides and a considerable number of books for reference have appeared.

When we consider the real nature of biological teaching, and the objects for which this teaching is done, we see the reason for this. Regarding laboratory work as the chief thing in all grades of work, which is certainly the attitude of most teachers, it is evident that this is the source of the only real knowledge that the student gets. The question, then, to

be solved is, what is the relation of other exercises to this work? Certainly it is not to tell the student anything which he might reasonably be expected to find out for himself, but primarily to arouse him to work, to stimulate an inquiring turn of mind, and to give general directions for methods of procedure in the laboratory; but we must remember that the time allotted to courses is usually far too short to enable a student to acquire for himself as extended and symmetrical a knowledge as he should have. He may study types of different groups, and yet may have no knowledge whatever of the groups as a whole. Although observation is an important part of all work in biology, still other things must be considered, and when students are sufficiently mature their observations should be united together and points brought out which they could not at all be expected to make out for themselves. The teachers of the country are overwhelmingly of the opinion that lectures constitute the best means of furnishing this additional information. "The object of lectures," says Professor Huxley,* "is, in the first place, to awaken the attention and excite the enthusiasm of the student, and this, I am sure, may be effected to a far greater extent by the personal influence of a respected teacher than in any other way." When we consider the great tendency of students to rely implicitly on book statements, and to forget that nature is the ultimate source of all scientific knowledge, we see another strong reason for reducing the amount of bookwork to a minimum, especially in the early stages of a biological course. That there are defects in the lecture system no one can deny, and that the system in the hands of incompetent teachers is open to abuse is still more evident. This was made clear in the report to the American Association, already quoted, in which it is stated that "the method does not remove the book that the pupil may come at the phenomenon, but it removes the book that the teacher may take its place. * * * There is only the substitution of a superficial class activity for the more deliberate work of the individual pupil. More mental effort is required on his part to get a lesson from a book than to listen to a lesson given by the teacher. * * * Where it is all talk and no work, and text-books are filtered through the very imperfect medium of the ordinary teacher's mind, and the pupil has nothing to do but to be instructed, every sound principle of education is outraged and science is only made ridiculous." But this applies to the schools rather than the colleges, and when we consider the present unsettled condition of the question, the appreciation of the difficulties on the part of the colleges, and the increasing preparation for science teaching which they afford, we may with confidence expect that many of the existing evils will soon be remedied.

THE PLACE OF BIOLOGY IN A GENERAL EDUCATION.

Having thus reviewed the character of work found in our schools and colleges, and endeavored to show something as to the opinions of lead-

*Lay Sermons, p. 110.

ing educators with regard to the best methods of conducting such work, we are led to ask, in conclusion, upon what does biology base its claim to the prominent place which it now enjoys in college courses? Many facts must be borne in mind in attempting an answer, but with special care must we distinguish between the claims of discipline and utility.

Regarding education as a process of development to fit one for the ordinary duties of life, without reference to any special profession, we rate the educational value of any study by the extent to which it trains the student in the mental process of which he will make use in after life. A youth of college age, who has spent the greater part of his life in acquiring facts and following out ready-made lines of reasoning, will probably have found the principal exercise of his own originality in framing mnemonic devices. In such work there is no appreciation of the value of the discipline involved in acquiring facts, and nothing to cultivate a habit of independent reasoning. Remembering that there is no pursuit in life in which success does not depend, in great measure, upon a close study of varying conditions, and the accuracy of judgments based upon these, we see the insufficiency of any course of study in which all reasoning is deductive in character.

In some respects the discipline derived from biological study is the same as that gotten from any other science, but there is this important difference, that physics and chemistry are more advanced, and consequently more deductive than biology. Of course this does not detract from the educational value of these subjects, for inductive methods may be and are successfully used in teaching them, but the fact that in the biological investigations of the present day inductive methods have still so important a part, is sure to have its effect through the teacher upon even elementary biological instruction.

With regard to the practical value of biological knowledge little need be said. The situation is much the same as in other sciences, in which it is almost invariably true that when cultivated for practical ends much of the distinctive culture is lost. The training through which one must pass to become an official entomologist or mycologist is of necessity one-sided. The attention of the student is drawn away from those parts of the subject having the greatest disciplinary value and kept fixed upon matters with which he must be familiar for the successful pursuit of his work. In the relation of biology to medicine the case is somewhat different. The intimacy of this relation has long been insisted upon in recognition of the fact that a knowledge of disease can only be based upon a sound understanding of the organs of the body in health, and further, that the most natural approach to the complex conditions found in the human body is through a study of lower animals, in which we find all the manifestations of life in a simpler form. But in this instance the claims of utility and general discipline are not antagonistic, for a maximum of each can be obtained without sacrifice of the other. We contend simply that the preparatory course of a physician should include,

constant practice in inductive reasoning, because he must constantly employ it in his profession. We believe that biology should be made prominent, because it furnishes at least as good a subject for teaching inductive methods as any other science, and has the additional advantage of giving information which must be of value in broadening the student's views of life and better fitting him for the minute study of its highest form.

In many of our colleges biology is an elective subject, standing in this respect on a common footing with the other sciences. Under existing circumstances many things may influence the student in his selection, but it is usually found that biology attracts quite its fair share of students. With the difficulty of avoiding an overcrowding of subjects in a college course, as well as with the claims of other sciences for recognition, we have here no concern. With regard to the claim of biology to a place in any liberal course we adopt the words of Professor Huxley:

Leave out the physiological sciences from your curriculum, and you launch the student into the world undisciplined in that science whose subject-matter would best develop the powers of observation; ignorant of facts of the deepest importance for his own and others' welfare; blind to the richest sources of beauty in God's creation; and unprovided with that belief in a living law, and an order manifesting itself in and through endless change and variety, which might serve to check and moderate that phase of despair through which, if he take an earnest interest in social problems, he will assuredly sooner or later pass

CHAPTER V.

UNIVERSITY WORK IN BIOLOGY.

If we take but a hasty glance over the many institutions of the country having the ambitious title University, the question strongly suggests itself with regard to a large number of them, Whence comes their right to the name? How do they differ from institutions that are content to rank merely as colleges? How are they better equipped for work, and how do their aims and characters differ? We find the name given to institutions which have but small faculties, inadequate equipments, and one or two prescribed courses leading to the ordinary bachelor degrees, with sometimes additional courses in law and medicine; but a study of the catalogues of such institutions usually shows that they have neither faculties nor equipment adequate to do the work which they profess to do. As Ex-President A. D. White remarks:

While at one end of the system we have institutions like Harvard, Yale, Columbia, Princeton, the Universities of Virginia, Pennsylvania, Michigan, and others bearing the names of States, with Johns Hopkins, Cornell, and Tulane, each of them, as a rule, expending several hundred thousand dollars a year, and showing that it can not meet the demands upon it even with these great sums, we have at the other end, and indeed throughout the greater part of the mass, institutions claiming to do university work with an entire invested endowment less than the smallest of the sums annually used by either of the institutions above named.

Table 1 is constructed to show something as to the size and character of American universities.

GENERAL CHARACTER OF UNIVERSITY WORK.

If we limit our conception of a university to those institutions which "strive to represent and embody the totality of human knowledge, and to find room for all forms of intellectual activity," we will find that a large number of our universities fall so far below this mark as to be scarcely worth considering. If we endeavor to set up an ideal of university work, to determine what is the real nature of the work of universities as opposed to that of the colleges, we meet with this difficulty, that we have no fixed standard by which the province of the university can be judged. The boundary line has not been sharply drawn in practice, for any one constructed in theory is constantly crossed from both sides.

If we turn to foreign countries to study their ideas of university work we are but little better off. In England we fail totally to distinguish between the colleges and the universities. Their work is one and the

same. The colleges make the university. Moreover, still further from our own ideas are those boards of examiners which call themselves universities, but which furnish no teaching. In this connection a quotation from Cardinal Newman is of interest:

A university in its simple and rudimental form is a school of knowledge of every kind, consisting of teachers and learners from every quarter. Many things are requisite to complete and satisfy the idea embodied in this description; but such a university seems to be in its essence a place for the communication and circulation of thought by means of personal intercourse through a wide extent of country. * * * It is the place to which a thousand schools make contributions; in which the intellect may safely range and speculate, sure to find its equal in some antagonistic activity, and its judge in the tribunal of truth. It is a place where inquiry is pushed forward, and discoveries verified and perfected, and rashness rendered innocuous, and error exposed by the collision of mind with mind and knowledge with knowledge.

Turning to Germany we find a closer resemblance to our own system, so far, at least, as the gymnasium answers to what our colleges were up to a short time ago. There the university courses are planned upon the assumption that students have had the preliminary training afforded by the gymnasium, to which they form the logical conclusion. The one leading characteristic of German university work, so far as can be stated, is its extreme specialization, even within the limits of a single subject. As a result of this we find the German universities noted for a degree of productiveness that is not attained under any other system. Even the smallest of them is actively engaged in adding to knowledge, and every student who enters their gates is supposed to be ready to begin work of this character. During his connection with the university original research occupies the greater part of his time, while his general culture, even in his own department, depends more upon his individual efforts.

Attempting to measure our American universities by these standards, we find that many of them fall far below. While our own conditions are peculiar, and while it necessarily follows that the American university, being the product of American ideas and conditions, must be to a great extent different from those of other lands, still it remains for the future to show just what the American university will be and how it is to be adapted to the needs of the age. In one point, at least, the character of university work is already clearly defined, for we notice that original research of some kind constitutes a large part of the work of every institution with any ambition and at all deserving of the name university. In this respect we see a strong leaning toward German models, which is readily understood when we remember how many of our own college and university professors are graduates of German universities.

If we consider original work to be the only or even the leading function of the university we make a grave mistake, for it is admitted in all countries that a university should be a great center of instruction. Here we find the greatest difficulties in deciding between the scope of

college and university work. We must bear in mind the conflicting claims of different departments of knowledge in attempting to arrange symmetrical college courses, but in the university we must offer everything that a student could wish to follow. On the one hand, work must be well rounded, general, and disciplinary in tendency, while on the other, the greatest freedom of choice must be allowed. Specialization is here a matter of necessity, but there is reason to believe that the intense specialization in a single department, so common in the German universities, will be largely counterbalanced by work of a more general character in the best American institutions.*

But a university must keep pace with the growth of knowledge and make the most thorough provision for instruction of the most special kind. To this end specialization on the part of faculties must increase. The time was when university work in biology might have been directed by one or two men. Now a university could scarcely regard itself as fully equipped for biological research without at least six full professors and a considerable number of assistants. Vertebrate and invertebrate morphology can hardly be intrusted to the same hands, and the same is true of phænogamic and cryptogamic botany, as well as animal and vegetable physiology, to say nothing of other subjects equally important, and if universities are to provide for all subjects on such a scale as this, it is at once evident that the matter of expense will become very great, perhaps even greater than the resources of the largest and wealthiest institution can stand. How this difficulty will be met is one of the matters for the future to decide, but even at present we see evidences of a disposition on the part of some to restrict the number of departments in which instruction is furnished, but maintain the greatest possible thoroughness in each one of them. President Hall, of Clark University, thus expresses himself on this point:

Each science has become so vast and manifold that it is impossible to cultivate the frontier of all at a single university. This is more and more recognized abroad, and is still more true under our American system of private endowment than on the European plan with a national treasury to draw from. If coming universities instead of imitating will supplement others, will elect each its group of studies, all the gain in economy and effectiveness which skilled labor has over unskilled will be secured in the field of highest education.

A few years ago it would have been difficult to show why the name university should be applied to any one of our American institutions.

* It would be foreign to our present subject to criticize the possible failures of the German system to secure the best results in preparing men to teach biology under American conditions as they now exist. We here note only one point, viz, that the development of science seems to be more highly esteemed than the symmetrical development of the individual. When we remember the small number of institutions in our own country that have or are likely soon to have more than one or two men in charge of the biological work, we see the necessity for a symmetrical training, and it may be questioned whether the training of the German system is not considerably in advance of the conditions which we now find in this country. This point will be considered further on.

Now, it is highly gratifying to see that we have several deserving of the name by reason of every test that we can apply. It is indeed flattering to our national pride to have it said by so judicious and impartial a critic as Mr. Bryce that "the great universities of the East, as well as one or two in the West, are already beginning to rival the ancient universities of Europe. They will soon have far greater funds at their command with which to move towards the same ideal as Germany set before herself; and they have already what is better than funds, an ardor and industry among the teachers which equal that displayed 50 years ago in Germany by the foremost men of the generation which raised the German schools to their glorious preëminence."*

But we are here concerned only with the biological work done by American universities, and to this end it is our task to look through the list and endeavor to find out what we can in regard to the present status of higher instruction and investigation in biology, and to determine as far as possible how such work is regarded, both by those who are themselves engaged in it, and hence fitted to speak with authority, and also by those who look from an outside position, who give biology only an equal rank with the other sciences, and who estimate scientific advancement by the intimacy of its relation to the good of humanity.

EARLY PERIOD OF BIOLOGICAL INVESTIGATION.

While the limits of this work will not permit any extensive survey of the workers and works of early times, still, in order to properly appreciate the research which is now going on, it is necessary to present a brief sketch of some of the more illustrious American workers whose main task was the description and classification of the flora and fauna of the United States, together with the dates of their principal works.†

The first native American who reached a prominent place as a botanist was John Bartram. While he made no descriptions of plants, his fame rests upon the fact that he discovered vast numbers of new plants, many more than any of his contemporaries. About 1730 he began to make collections and continued this work for many years.

In 1732 Mark Catesby published the first volume of his *Natural History of Carolina, Florida, and the Bahamas*, the second appearing in 1743. These contained descriptions of many new southern plants and birds.

* American Commonwealth, vol. 4, p. 553.

† We are here concerned only with work done by Americans, and especially that which has had the most important influence upon the investigations of the present time. For further details in regard to this matter the reader is referred to a most admirable study by Dr. G. Brown Goode, published in three distinct articles, "The Beginnings of Natural History in America," and "The Beginnings of American Science. The Third Century," delivered as presidential addresses before the Biological Society of Washington, in 1886 and 1888, respectively, and "The Origin of the National Scientific and Educational Institutions of the United States." G. P. Putnam's Sons, 1890.

The name of Cadwallader Colden should be mentioned in connection with the study of the plants of New York State, which he began to make about 1739 and continued for a number of years.

In 1740 John Mitchell published a description of about thirty new genera of Virginia plants, while in 1785 Rev. Manasseh Cutler published the first attempt at a scientific description of the plants of New England.

In 1791 William Bartram published an account of his southern travels, in which he gave descriptions of large numbers of new southern plants.

The year 1792 is noteworthy as being the date of the first organized work in economic entomology, a committee having been appointed by the American Philosophical Society to prepare a report on the Hessian fly, which had already done great damage to wheat fields.

In 1794 was published the first paper by a native American dealing with descriptive zoölogy, "A description of four remarkable fishes taken near the Piscataqua, in New Hampshire," by William Dandridge Peck, and shortly after appeared some descriptions of North American fungi by the same author.

The first volume of Alexander Wilson's Ornithology appeared in 1808 and the publication continued until 1814, when the ninth volume was finished.

In 1816 Stephen Elliott began the publication of his Sketch of the Botany of South Carolina and Georgia, which contributed greatly to a knowledge of southern botany, and in the same year appeared the first work by Thomas Say on conchology. In 1817 Say produced his work on systematic entomology, and followed this in later years by descriptions of marine invertebrates, especially crustacea and reptiles.

In 1818 Thomas Nuttall published a most valuable work on the "Genera of North American plants." In this he gave descriptions of many new species. He also made some descriptions of new birds.

In the subsequent year Dr. John Torrey began to publish, his first paper being devoted to the plants near New York City. In 1824 he began an account of the flora of the northern and middle sections of the United States in accordance with the Linnæan arrangement, but this work was not completed.

The Fauna Americana, by Richard Harlan, appeared in 1825, followed by Godman's work on North American Mammals, published in 1826-28.

In 1827 appeared the first volume of that most remarkable work, Audubon's "Birds of America," the text and plates not being completed until 1839.

This brief sketch brings us nearly to the limit of the early period of work in botany and zoölogy, for all that was done subsequent to 1840, or thereabouts, belongs rather to the present than the past. Looking back over this early period it is at once noticed that botany attracted more attention than zoölogy, but that the work first done in both sub-

jects was of the same character. In any new country the progress of work in natural history must be much the same thing. Simple observation and description of its plants and animals must come first, and it follows in the nature of things that these descriptions must be revised and corrected and much time consumed before a comprehensive classification that will stand the test of time can be made. Physiological work is not likely to attract much attention until descriptive work has advanced very far.

The early naturalists of the country were not specialists. Many of them worked in several departments (as we now class them) of natural history. Botany attracted attention from many of them, and single individuals usually accomplished more in this than in other fields, owing to the readiness with which the work can be performed. As we would expect, we find little or no attention given to the lower plants, and likewise we notice that the most common and conspicuous animal forms were those which first received attention.

Looking back over the early history of science in this country we meet with the anomalous fact that most of the biological research, the very kind of work which we have regarded as the special duty of universities to conduct, was largely the work of men who were in no way connected with universities. These men worked under the disadvantage of isolation, and lacked the stimulus that comes from association and interchange of ideas with those following similar pursuits. They continued to work simply because there was deeply implanted in their natures an irresistible desire to acquire this knowledge for themselves. There has been a tendency on the part of certain writers to underrate the value of their work, but surely anyone disposed to criticise must remember that the natural order of development of science requires that its whole superstructure be raised upon the solid foundation of accurate description and classification. This work was done by our earliest naturalists, and well done, leaving those of the present day free to devote their energies to matters of a different nature.

While much of the early work in botany and zöology was done in the face of discouragements, this was not true of all. The organization of the American Philosophical Society in 1769, and of the American Academy of Arts and Sciences in 1780, had the important effect of bringing together scientific men from all sections of the country, and taking the place, to some extent, of the college association which many of them lacked. They furnished a means of bringing new discoveries to the notice of scientific men, while their "Philosophical Transactions" and Memoirs gave publication to all that was brought before them.

We may here mention two other movements in the same two cities which had a most marked effect upon biological research in early times. In 1812 there was established the Philadelphia Academy of Natural Sciences, which at first contained few scientific men, but afterwards changed in this respect. Under its auspices in more recent times large

collections have been accumulated and important investigations completed. In 1814 "The New England Society for the Promotion of Natural History" was organized in Boston. In the following year its name was changed to "The Linnæan Society of New England." Its members were all investigators, and plans for coöperative work were made, but the project was abandoned in 1822, after having brought together collections of considerable size and value. In 1830 this was reorganized as the Boston Society of Natural History, which has continued up to the present time to exert a most important influence upon biological investigation. Large collections have been brought together, and by means of the Walker prizes the society has been able to do much in stimulating research. It has done good service, too, by its publications. In 1834 the Boston Journal of Natural History began to be published under its auspices, and in 1864 these gave place to a larger series of "Memoirs," which still give publication to many important papers. Popular lectures are given at irregular intervals, but still more important is the actual work of teaching, since the society provides regular courses of instruction and furnishes facilities for laboratory work. Its connection with marine laboratory work will be referred to in chapter VII.

It is a striking fact that the leading members of these societies were usually men prominent in political affairs. Benjamin Franklin was first president of the American Philosophical Society, while the American Academy was founded largely through the exertions of John Adams. In fact, during the first quarter of a century of the existence of our Government its control was largely in the hands of men who were not only in full sympathy with scientific research, but were themselves engaged in it. One prominent example only need be here mentioned—Thomas Jefferson's "Notes on Virginia." In this book the natural history of the State was fully treated, and it was by far the most important book that had appeared up to that time. Its importance depended upon the impetus which it gave to scientific work rather than upon the amount of new matter which it contained.

The repeated attempt to found a national university, and the oft repeated statement that research should form a part of the work of such an institution shows that the minds of those most interested in the work of education had clearly apprehended the fact that the work of the investigator is best done when many workers are together, and that the work of teaching had a beneficial effect upon the quality of investigation. Impracticable as the project proved, it still had its effect, for it was the plan of its promoters to carry through as much of its organization as possible and secure from Congress everything that they could that might have its use when the entire plan could be carried into effect. The Botanical Garden was one of Washington's original plans in connection with the national university movement. It was first

established in 1822 or 1823 and moved to its present site in 1852, and it constitutes the only result of that movement now remaining.

From the earliest times a disposition has been manifested by the Government to aid scientific work of all kinds, but the character of work done was, at least at first, that which seemed to be most pressing by reason of its direct economic value. We find, therefore, that the exploration of the country, and the establishment of the Coast Survey, Astronomical Observatory, and Signal Service were the principal events prior to 1840. But bearing in mind the character of biological work done at that period, it is evident that the exploration of the country was the most valuable aid that could have been rendered. The principal needs of the investigations of that early period were new objects of study, and we find that the expedition of Lewis and Clarke begun in 1803, and the expedition of General Pike shortly after, as well as numerous expeditions subsequently sent out, were of the greatest value in bringing to the notice of biological workers large numbers of previously unknown plants and animals. The Wilkes expedition, sent out in 1838, with special reference to the whale fisheries of the United States, was also rich in scientific results, among which Dana's study of corals and the work of Gould upon the mollusca were especially noteworthy. We shall have occasion later to refer to the more recent actions of the Government in directly aiding biological work.

MODERN PERIODS OF BIOLOGICAL INVESTIGATION.

It is difficult to define sharply the exact beginning of the new era of biological work, and none the less so to give its causes. The tremendous tidal wave that swept over the country at about the time that steam and electricity began to come into general use had its effect upon the character of investigation in all sciences. It has been stated that the new period of biological work began with the advent of Agassiz in this country, but it is certainly true that the influences which brought him here were due in great measure to the general awakening of science, and to conditions peculiar to this country. The date of this change may be put at about 1840 or slightly later. In all the work done prior to that time we notice a more or less fragmentary and disconnected character. Not only were investigators working largely by themselves, but they lacked the system and stimulus coming from a knowledge of the fact that their work bore directly upon a theory. They were laboring to add to knowledge, but worked upon anything that happened to present itself. Most that they did was purely observational, and the early period produced but few experimenters.

About the year 1840 this began to change and work began to assume a much broader aspect. This year witnessed the organization of two societies of great importance—the National Institution for the Promotion of Science, and the American Society of Geologists and Natural-

ists. The former was but short-lived. It had a large membership and was exceedingly prominent while it lasted. The latter, 10 years after its foundation, became the "American Association for the Advancement of Science," one section of which is specially devoted to biological work. The first indication of the change may be placed at 1834, when Prof. Asa Gray published his first paper on the gramineæ and cyperacæ of North America. Prior to Professor Gray's activity botanists had confined their work to more or less limited groups of flowering plants, and while his works continued to be mainly in this same line, yet one of his early papers, published in 1846, was written in conjunction with W. S. Sullivant, on the Mosses of the Alleghanies, and the study of lower plants generally was favored and encouraged by him. His influence in broadening botanical research must therefore be regarded as of the highest value.

The most important event in the history of biological research in this country is the advent of Professor Agassiz in 1846, for soon after, as soon as his influence had time to diffuse itself, work in zoölogy began to change its character. With Agassiz there began a broader, more comprehensive study of animals than had ever before been made. His pupils were instructed in the methods of embryological and morphological study introduced by Cuvier, Von Baer, and Agassiz himself, and catching the enthusiasm of their instructor, they produced results of the greatest importance, and far surpassing in value anything that had previously been produced. The published papers to which reference is made are too numerous and too readily accessible to justify any extended mention of them here, many of them, indeed, being the work of men still living. We need only mention the names of Alexander Agassiz, Brooks, Fewkes, Hyatt, Joseph LeConte, McCrady, Morse, Niles, Packard, Scudder, Shaler, Verrill, and Whitman, all of them pupils of Agassiz, to show the tremendous extent of his influence. It is difficult, within brief limits, to sharply characterize the modern tendency of biological research, and yet the work accomplished since the time when Agassiz's influence began to diffuse itself, differs markedly from that of the earlier period in that it was mainly suggested by and undertaken because of its bearing upon a definite theory. It was Agassiz who reduced to order the sum of existing knowledge with regard to the relations of existing animals to extinct ones, as well as adding greatly to it. He pointed out the resemblances shown by certain animal forms in their individual development to the order of succession of the geological record, and opened the eyes of investigators to the enormous possibilities of further work in the same direction upon other animal groups. This alone was enough to greatly influence the work of the country, and its effect is still felt in all of the work going on at the present time.

It must not be understood that the systematic work of the early period was replaced by embryological work, but rather that the results of embryology must be included in any correct system of classification. Bio-

logical work no longer consists in labeling plants and animals, but in the wider and more extended problems of the present day, the attempts to determine real relationships which are expressed in classifications, individual development must be taken into account as well as adult features. The systematic work of the present period, influenced first by Gray and Agassiz, and later further expanded when the work of Darwin furnished new problems, is being more limited and at the same time more extensive. We find special groups of plants and animals becoming the subjects of elaborate monographs, and we see workers beginning to devote attention to more limited fields.

Among the important events of the memorable year 1846, was the establishment of the Smithsonian Institution and the beginning of the National Museum. The Smithsonian Institution was established from a fund left by an Englishman, James Smithson, with which "to found at Washington an institution which should bear his own name, and have for its objects the 'increase and diffusion of knowledge among men.'" Among the important services which it has rendered to biological advancement, is the publication of twenty-six quarto volumes of "Contributions to Knowledge," which include many biological papers, as well as the annual reports of the secretary, containing valuable accounts of current work for the year.

The National Museum dates back to the same year (1846). At first it consisted merely of a collection of various curiosities which were stored in the Patent Office. In 1857 this collection, which had by this time grown considerably, was passed over to the control of the Smithsonian Institution. Professor Henry, who was secretary up to 1878, had little sympathy with the idea that a museum in itself possessed any special value, and he would willingly have given away all of the zoölogical material after the investigations upon them had been completed. In 1850 Prof. Spencer F. Baird was appointed his assistant, and owing entirely to his exertions the zoölogical collections began to increase rapidly in size. These were at first mainly gifts from private individuals. Later the Fish Commission and the Geological Survey became important sources of new material. The appointment of Professor Baird as secretary in 1878, and the transfer of the general oversight of the museum to Dr. G. Brown Goode in 1879, were most important factors in making the zoölogical collections what they now are, and in bringing about the present systems of arrangement and labeling, which made the Museum a much larger factor in public education than it had ever previously been, as well as making it more accessible and valuable to the investigator.

NATIONAL AID TO BIOLOGICAL WORK.

The National Government has been and is still supporting several scientific movements which have a more or less direct bearing upon biological research. The beginning of this may be put at 1854, when

Townend Glover was appointed entomologist, and in the succeeding year botanical work was also undertaken. The value of this work, done necessarily on a limited scale and with special reference to economic questions, was so apparent that the organization of the Department of Agriculture followed in 1862. In certain directions, especially the study of the life histories of insects and fungi, this has exerted a great influence upon purely scientific research. In the same year, and intimately related to the Department of Agriculture, occurred the most important educational movement ever undertaken by the Government, viz, the appropriation of public lands to each of the States for the support of the so-called "agricultural colleges." As a result of this act we now find that forty-six States and Territories are maintaining institutions entirely or in part from this appropriation, and while it is by no means true that these are agricultural colleges in a narrow sense, it is true of most of them that the bearings of biology upon agriculture are fully appreciated, and their teaching conducted accordingly.*

In this connection may be mentioned the act of Congress in 1887 which provided for the establishment of experiment stations in connection with the above colleges. The objects of these stations are, among other things, "to conduct original researches or verify experiments on the physiology of plants and animals; the diseases to which they are severally subject, with the remedies for the same."

The experiment stations have not yet been long enough organized to bring forth fruit in great abundance. In many States they are scarcely yet fully under way. In certain cases the character of work done is on a much lower plane than in others, and yet time will probably remedy the present defect, and the scientific results that may be accomplished it is difficult to overestimate.

The most valuable aid to biological research given by the Government was the establishment of the Fish Commission in 1871. Organized for the purpose of studying the life histories, modes of propagation, and enemies of food-fishes, it has now come to be a most important aid to the students of marine animal life generally. Its relations to the National Museum are most intimate and it really serves as the most important means of acquiring new zoölogical specimens. To the credit of the Government be it said that the appropriations to the Fish Commission have always been liberal, and that the work done has not by any means been confined to work of a purely economic value. The laboratory at Woods Holl, constructed in 1884, is open under certain restric-

* The original endowment of the agricultural colleges was derived from the sale of public lands, 30,000 acres being appropriated for each Senator and Representative in Congress. The total amount of land given by the General Government to the States is 1,995,920 acres. The extent and usefulness of these institutions has so increased that the endowment has been felt to be inadequate. Congress, therefore, in 1890, passed an act donating \$15,000 to each State, the sum to be increased by \$1,000 yearly until the appropriation reaches \$25,000, which shall be a permanent income.

tions to investigators who avail themselves of the facilities for collecting and the appliances which the laboratory affords. In addition to this the study of invertebrates is regularly provided for, being placed under the general charge of Prof. A. E. Verrill, of Yale University, while the various groups are intrusted to those making a specialty of their study. The Fish Commission and National Museum have together done a valuable service in contributing duplicate material arranged and labeled to the museums connected with educational institutions.

Mention has already been made of the most prominent scientific associations which exerted an influence upon biological research prior to the advent of Agassiz. We may now refer briefly to some that have since been organized.

In 1863 the National Academy of Sciences was established by Congress. It had an unlocalized membership, and was designed "to guide public action in reference to scientific matters." In its proceedings numerous biological papers are to be found.

The most important organization for influencing the character of biological teaching in this country is the American Society of Naturalists of the eastern United States. This was founded in 1881, not for the presentation and discussion of researches, so much as for the consideration of educational and other matters of general interest to working naturalists. Its membership is unlocalized, but limited to investigators.

Following this, in 1887, the American Physiological Society was organized. Its membership is likewise unlocalized, but limited to investigators, while its object is "to promote the advance of physiology and to facilitate personal intercourse between American physiologists."

PRESENT ASPECT OF UNIVERSITY WORK IN BIOLOGY.

We have now advanced to a stage where we can no longer expect much biological research to be done by private individuals, and we must look largely to the colleges for work of a purely scientific character. We need have but little fear that economic investigation will suffer. Government specialists stand ready to undertake any biological work having a direct bearing upon the welfare of the country; but even in the purely scientific work of the Department we observe that men connected with colleges are frequently employed.

The reason for this is evident when we consider the character of the problems now awaiting solution and the conditions under which research can be brought to a successful issue. Many problems are peculiar to this country, arising out of the character of its flora and fauna, while, on the other hand, certain kinds of work find in this country more favorable conditions than elsewhere prevail.

Considering purely descriptive work, both in botany and zoölogy, we find that there is still much to be done. There are yet many regions to

be explored before we will know the entire flora and fauna of the United States, and our knowledge of the life histories, especially of the lower vegetable forms, is in a peculiarly unsatisfactory condition.* Certain it is that at present systematic work can not be done away from large collections such as only large institutions are apt to possess, and it is certain that the progress of biology is hindered rather than helped by attempts to describe new plants and animals on the part of those who have not access to sufficiently large museums and herbaria to make their work conclusive. Professor Farlow has strongly urged that systematic work be left entirely to those having every facility for it, and has pointed out that histology and embryology furnish the problems best fitted for those not so well situated.

We have up to this time emphasized only the functions of the university in advancing knowledge, but it must be remembered that the universities are expected, in addition, to furnish teachers for the institutions of the country. Higher instruction must, therefore, be provided as well as facilities for investigation. In biology this is peculiarly necessary, for it is perhaps easier here for an investigator to become absorbed in his own specialty and lose sight of other divisions of the subject than in other branches of science. Coöperation among investigators is peculiarly necessary if the best results to the individual are to be reached, while specialization of research is equally imperative for the best interests of science. At present, in this country, these two points are not equally guarded, for we do not find sufficient efforts made to resist the narrowing tendency of specialization. Under the head of university instruction we would include all special lecture courses, consisting of presentations of standard researches, expositions of important theories, and all studies of current literature. Work of this kind might, of course, be done by any one student for himself but for the fact that the amount of ground which it is desirable to go over is too great and a division of labor is essential for the best all-around results. Prof. C. O. Whitman † has in forcible terms pointed out the necessity for organization among investigators, and as a result of his efforts there is a much more widespread appreciation of this necessity than ever before. At the Johns Hopkins University there have been advanced lecture courses and coöperative studies in current literature ever since its foundation. In but few other institutions do the catalogues contain any accounts of such work, and in most of these the influence of Johns Hopkins is directly seen. But the present indications are hopeful. The necessity for such work is coming to be generally felt, and the means to do it will assuredly follow.

The question may well be raised whether as much original investigation in biology is being made in America as should be expected, but in attempting to answer it we meet with difficulties. We can perhaps

* See "The Task of American Botanists," by W. G. Farlow, *Popular Science Monthly*, July, 1887.

† *Biological Lectures*, 1891.

best arrive at definite results by comparing our own country with others and taking into account all the points that can be determined which bear upon it.

The character, number, and acknowledged importance of the scientific periodicals published in any country constitute the best index of the amount and quality of research that is accomplished. Judged by this standard we find that Germany at least is far in advance of this country. On looking into the character of work done in Germany we find that many subdivisions of biology are about equally well provided for, while we find several journals of a high order devoted to systematic zoölogy and embryology; we find almost as many devoted to physiology, and structural as well as systematic and physiological botany are well provided for. Many of these journals are more or less intimately connected with the universities and were originally established for the publication of their own researches.

If we contrast this with the state of things in our own country, we find that few strictly scientific biological periodicals exist, and many of these are subject to restrictions with regard to contributors. While we have such journals as the *Botanical Gazette* and the *American Naturalist*, yet it may truly be said that until the establishment of the *Journal of Morphology* in 1887 we had no journal open to all the workers of the country that was on a sufficiently firm financial basis to undertake the publication of extensive researches involving numerous plates. The "*Studies from the Biological Laboratory*" of Johns Hopkins University, and the bulletins of the Museum of Comparative Zoölogy at Cambridge have been of great value in furnishing publication for many important investigations in zoölogy and physiology, but these journals are unfortunately open only to workers at the institutions from which they are published.

Valuable service has been rendered by various societies in giving publication to biological articles. The Boston Society of Natural History has been especially active, and the Smithsonian Contributions to Knowledge also contain many valuable biological papers. The General Government has also given publication to many researches which otherwise might never have been made public.

If we consider the contents of these journals it is evident that botany receives much less attention than zoölogy, while the amount of work done in animal, but especially vegetable, physiology, is exceedingly small. The total number of institutions claiming to do university work is in striking contrast with the amount of work produced. After making due allowance for the amount of research conducted under Government aid, and the various academies of sciences, it is seen that the colleges are doing very little to advance the sum of human knowledge in this direction at least. But the reason of this is not far to seek. Looking over chapter II with special reference to the universities, we find that very few of them are equipped for research in any department.

But the true solution seems to be found in table 1, which shows the unreasonable and short-sighted policy pursued by so many boards of college trustees throughout the country. Out of one hundred and eleven colleges there are but forty-one in which the biological departments are in the hands of men who have no other teaching. In twenty cases geology is added, while thirty professors of natural science are found. If to this we add the fact that in sixty-nine cases the instructor in charge has no assistant, it is evident that to expect any research to be made under these circumstances would be unreasonable in the highest degree.

It must be admitted that for this state of things teachers are themselves, in large measure, responsible. They have so long and so earnestly insisted upon the value of biology as a means of discipline, and so greatly developed the methods of instruction, that their claims have at last met with something like adequate recognition, but the result is that every teacher is now oppressed with a great burden of elementary teaching for which the modern methods are much more laborious than those formerly employed.

But this would, in all probability, apply with nearly equal force to work in all branches of biology, and we have not yet explained the great predominance of work in zoölogy over that in other subjects. Professor Farlow* regards the small amount of work in botany as due to radical defects in the methods of teaching in vogue some years ago, and still not out of use, for he maintains that the effect of these methods was to drive away students, who, if properly trained, would have done botanical work of good quality. Professor Martin† has expressed the opinion that America has not contributed her fair share toward the advancement of animal physiology, and we shall later see that there are, at the present time, but few colleges provided with an adequate equipment for investigation of this kind. Most of the physiological work done in this country at the present time is done by the medical schools, and physiology only rarely comes within the jurisdiction of the "faculty of philosophy," as in other countries.

In this connection we should remember that this country is especially a favorable place for physiological work, as compared at least with England, where all work has virtually been stopped by antivivisection laws. In spite of repeated fanatical attempts to prevent vivisection in various cities in this country, many of which have been directly due to the efforts of the "Victoria Street Society for the Prevention of Vivisection;" in spite of attempts to convince the public that physiologists are engaged in torturing animals, not at all in the interests of science, but simply to gratify their own cruel passions, vivisection may still be

* Op. cit.

† Modern Physiological Laboratories; what they are and why they are. Johns Hopkins University Circular, 1882.

practiced in this country, and in spite of an increasing amount done, there are no indications of any restrictions being imposed.

There is yet a vast work to be done, and America is slowly awakening to the share which she may have in it. It makes but little difference whether this work be monopolized by medical schools or not. Whether the intimate relations existing between physiology and pathology shall take precedence over the idea that physiology is mainly physics and chemistry applied to living things, is a matter of little or no consequence. With regard to the bearing of physiological investigation upon the general work of a university, President Gilman, of Johns Hopkins University, speaks as follows:

A university should discover and teach all that can be known of the human body. If you ask me why this is so important, I reply, in order that everyone may be able to lead a healthier, stronger, and more rational life than is now possible for the want of more knowledge. Hospitals are essential to alleviate sufferings which have been encountered, physical training is of great value, but still more important to humanity is the laboratory in which are studied the laws of life. A celebrated physiologist declares that "a hundred years of life is what Providence intended for man," and others tell us that most of our minor ailments may easily be avoided, and the number of efficient days may be largely increased. Science has proved that many diseases which used to scourge the civilized world may be prevented, and it has recently brought us within sight of new discoveries which will still farther interrupt the progress of pestilence. The discoveries of anæsthetics have marvelously alleviated the sufferings of humanity. The causes and remedies of cerebral excitement and degeneration have never been understood as now, and the possibilities have never been so great for the restoration to their normal activity of the powers which have been alienated. In view of these great results and of these anticipations it is clearly the duty of a university to study all the forms and functions of life which are manifested in organisms lower than man, all the laws which govern animal and vegetable growth, all that can possibly throw light on human physiology.

Those who are devoted to research of this kind, revealing with their microscopes the structure and the life histories of the minutest organisms, are constantly and in the most unexpected ways coming upon new illustrations of the plan of creation, which have an important bearing upon the welfare of man. They are the interpreters of nature and the benefactors of humanity, and I do not hesitate to add that if there is any branch of learning which at the present time deserves the most generous support it is surely biology, because of its obvious relations to the health and happiness of every human being. I can not but think that those who oppose its study will be ranked in future years among the obscurantists of the nineteenth century.*

* A short time prior to the delivery of this address a strong but unsuccessful attempt was made to suppress vivisection at the Johns Hopkins University. It was due in part to English influences, but was rendered ineffectual by the prompt action of the university authorities.

CHAPTER VI.

LABORATORIES AND MUSEUMS.

With a unanimity that is surprising when we consider the importance of the subject involved, the institutions of the country report that they are conducting their biological work in rooms that were originally planned for some other purpose, and that are more or less ill-suited to the needs of a biological laboratory. Indeed, it is true of a goodly number that they have only their class rooms in which to conduct laboratory work. In several cases is the report made that new buildings have been erected for chemistry or physics, and that biology has taken what they leave. A diligent search through a large number of catalogues has failed to reveal more than five institutions in the entire country which possess separate buildings devoted to biology alone, erected for that purpose, and equipped in such a manner as to enable work to be done readily and conveniently. The facts indicate very strongly that there is a much more general appreciation of the validity of the claims of chemistry and perhaps physics to laboratory space and equipment than of biology.

While it is one of the striking advantages which biology possesses over other sciences that much can be done with a small outlay for apparatus, there is yet a point beyond which this does not hold true. While a laboratory may be rude and poorly equipped and yet be a "place where good, honest work can be done," this assumes that there is on the part of students a disposition to work faithfully in spite of disadvantages, an assumption which is by no means justified by the facts.

The equipment of a biological laboratory presents questions which are the same for no two institutions in the country. Prof. William A. Loey, of Lake Forest University, says upon this subject:

As a matter of course the needs vary greatly with the scope and importance of the work, but every college laboratory should contain enough microscopes for the individual use of students, water, work tables, a microtome of late pattern for cutting serial sections, means of imbedding in paraffine and celloidin, some of the current reference books, a Zeiss camera, or an embryograph of some kind, alcohol, reagents, and dyes. These are the staple articles of furnishing. Other accessories will correspond to the quality of the work the teacher is expected to conduct.

Perhaps the most defective point in the equipment of the college laboratories through the country, is that too small a number of duplicates is provided. The number of microscopes, for example, which every laboratory should possess depends upon the number of students and

assistants, but this general statement may be made that each laboratory should contain a number of microscopes equal to the largest number of students that can be properly supervised in the laboratory at one time. If there be a smaller number than this, teachers are caused to lose much valuable time in repeating work with different sections of the classes. Scarcely a letter was received by the writer which did not contain expressions of dissatisfaction over the poor equipment provided. One teacher, just moved to a new college, writes that "the college possesses but two microscopes, neither of which is in order." Another, connected with a prominent college, writes: "The professor is willing that the report should particularize —— College as being behind the age in these respects, but desires that the responsibility for this neglect should be placed upon the trustees, where it belongs."

But while the colleges generally are meagerly enough equipped for furnishing the necessary facilities for the mere observation of plant and animal forms, the situation is infinitely worse with regard to experimental work. Of course the difficulty of getting accurate accounts of laboratory equipments must be borne in mind, but so far as the writer has been able to learn, there are not more than five or six institutions in the country that furnish students with the means for performing even the simplest experiment in either animal or vegetable physiology. If we contrast this with the number of courses in physiology that are given in the country, we are convinced that whatever may be the object for which these courses are given, training in scientific methods is not one of them.

There are, to be sure, difficulties in the way of general laboratory work in physiology that do not exist in regard to other subdivisions of biology. A laboratory equipped with microscopes and the usual appliances, and also with needed arrangements for dissecting, is more expensive, perhaps, than a chemical laboratory equipped to the same degree of efficiency; but here the greatest expense is in the original equipment. A well-equipped physical laboratory may perhaps cost more than either, but the running expenses are certainly least of all. But if a biological laboratory is equipped with the means for performing physiological work and provided with a sufficient number of duplicates to enable the work to go on systematically and without inconvenience, the expense is carried up to a point which only a few institutions can stand. And yet the fact remains that much more might be done than is done, both because of the fact that many important experiments do not require expensive apparatus, and the fact that much may be demonstrated in a laboratory which does not furnish students with facilities for doing many pieces of work for themselves. "When the conditions are such," says Professor Martin, "that the students can not make experiments themselves, we insist that they shall at the least have shown to them the most important facts; that the lecture and the text-book shall have as their accompaniment, I might perhaps say as their basis, actual demon-

strations, supplemented if possible by personal experimentation by the learner himself. We ridicule the notion of any real teaching of physiology to a student who has never seen a beating heart, a blood-pressure experiment, or a demonstration of the action of saliva on starch."

The requirements which must be met in arranging laboratories for research are scarcely greater than for the work of teaching. Certainly this is true of work in either animal or vegetable morphology, for if an institution possesses rooms suitably lighted, provided with microscopes of sufficient range of powers, staining and mounting fluids, and the necessary apparatus for imbedding and for section cutting, and if in addition it possesses arrangements for procuring specimens in abundance, the morphologist finds most of his wants satisfied. So far as material equipment is concerned, while there are but few places where it is all that might be desired, there is a considerable number, as the preceding statements show, at which something might be done in morphological research.

With regard to animal and vegetable physiology the case is very different. While in the former much has been done with simple and inexpensive apparatus, the improvements are so great that for any extended research a considerable outlay is needed. With reference to animal physiology a glance over the literature will show how great a share the development of improved apparatus has had in eliminating errors and correcting erroneous ideas in regard to many of the fundamental processes in the body. Any adequate equipment for research in animal physiology must include many pieces of apparatus that are expensive, much elaborate recording apparatus, and many pieces of somewhat limited application and yet liable to be wanted at any time. A large stock of general apparatus is also desirable—pieces that can be readily utilized and from which special designs can be constructed. As a further desideratum is the ability to have apparatus readily constructed to meet special needs.

On looking through the list to determine the character of the various institutions with reference to their facilities for research in animal and vegetable physiology, we find that there is little to be said. Not more than three or four institutions are provided with the means for research in vegetable physiology, and only a slightly larger number are equipped for work in animal physiology. In regard to the latter it will be noticed that in nearly every case where provision is made for animal physiology the institution is in intimate relation with a medical school. Whatever be the character of the research actually performed, it becomes evident that physiology does not stand on the same plane as other sciences, but that research is directly influenced to a greater or less extent by its possible applications.

The number of institutions that have separate buildings devoted to biology is surprisingly small. So far as is known to the writer the Johns Hopkins laboratory was the first building of any considerable

size erected solely for biological teaching and investigation, and it has up to the present time been followed by only two laboratories, in eastern colleges at least—the University of Pennsylvania and the College of New Jersey. In each of these arrangements are made for elementary as well as for advanced work.

It has been long recognized that a museum is necessary for the work of teaching no less than research, and yet there is perhaps no point in regard to which opinions have more changed than the character of collections necessary for undergraduate work. Most of the institutions of the country report that they have collections of greater or less size. In the detailed statements of chapter II these have been described as fully as possible, and nothing need be here repeated.

If any general criticism may be made upon the college museums of the country it is that they are unnecessarily large for the work of teaching, and not large enough for research. The museums of the past were looked upon too largely as curiosities. They were expected to furnish entertainment rather than instruction. They contained too much useless material. Arrangement was usually conspicuous from its absence. It seemed to be the ambition of many colleges to bring together large collections rather than those possessing educational value.

At present there is a striking tendency to change in this respect and bring together smaller but carefully arranged collections. Indeed, on looking into the subject it is surprising to see how little will answer the purpose of instruction if it is properly selected.

To select a conspicuous example, the Johns Hopkins University possesses a museum which is contained in one small room. It includes a number of specimens which would be regarded as small, judged by common standards, and yet every animal subkingdom is represented by a sufficient number of specimens to give the student who studies it a fair idea of the animal kingdom as a whole. It contains a sufficient number of skeletons to make a thorough study of comparative osteology possible, and it also contains many representatives of the lower invertebrates, the number in each case depending in part upon the size of the group, and in part upon the amount of variation in form found within its limits.

This fact is not without its significance, for it indicates a disposition on the part of a prominent institution, possessed of ample means, to spend as little as possible upon collections, leaving more to be invested in a working outfit. It should be borne in mind, too, that the courses, being elective, are fuller than those commonly given through the country, and consequently make greater demands upon the collections for illustration.

Professor Spalding, of the University of Michigan, writes:

The time and thought of the botanical department for the last 10 years has been given to the development of biological instruction rather than to increasing collections. Here again the courses are elective and correspondingly full.

The museum of Cornell University is a notable collection of rare and interesting, as well as instructive, forms, and yet Professor Wilder writes in "Science:"

Instead of vainly attempting to obtain and exhibit all the species of all the groups, most educational museums would attain more satisfactory results by selecting the more interesting or instructive forms for all classes, and limiting their efforts to complete groups for a few upon which, as well as upon a large number, may be illustrated the principles of classification and of individual and geographical variation.

The same principle is recognized in the arrangement of the Agassiz Museum, in which synoptic rooms are everywhere provided, these being the rooms which are recognized as having the greatest educational value.

Enough has been said to show that at present small collections are coming to be regarded as sufficient for the ordinary work of instruction. There are but few educational institutions that can afford to keep up large collections for the entertainment or instruction of the public.

Such collections can only be maintained by government aid or by other special means. Indeed, although it is somewhat foreign to our subject, it seems likely that at the present time the value of such collections is overestimated, for with educational systems constituted as they now are, the public at large are totally unfit to receive the real benefit which they should derive from this source.

This was fully recognized many years ago. Professor Forbes in a lecture before the Royal School of Mines, delivered in 1853, speaks as follows:

Museums of themselves alone are powerless to educate. But they can instruct the educated, and excite a desire for knowledge in the ignorant. The laborer who spends his holiday in a walk through the British Museum can not fail to come away with a strong and reverential sense of the extent of knowledge possessed by his fellow men. It is not the objects themselves that he sees there and wonders at that make this impression so much as the order and evident science, which he can not but recognize, in the manner in which they are grouped and arranged. * * *

It is not the ignorant only who may benefit in the way just indicated. The so-called educated are as likely to gain by a visit to a museum, where their least cultivated faculties, those of observation, may be healthily stimulated and brought into action. The great defect of our systems of education is the neglect of the educating of the observing powers—a very distinct matter, be it noted, from scientific instruction.

When we consider the needs of the investigator in either systematic botany or zoölogy, we see that they are much more extensive than the work of teaching requires. So far is this true that there are but few museums or herbaria connected with colleges that are large enough to satisfy the requirements. Large size is here a necessity, and yet we find that the difficulty of collecting and the expense of preserving, especially animal forms, are so great as to be beyond the reach of more than five or six of our American colleges.

This fact early became evident to the trustees of the Agassiz Museum. In their report for 1875 the following statement occurred:

The great difficulty in preserving alcoholic collections, the unpleasant nature and enormous expense of the work, make it imperative, not only for storage but still more for exhibition purposes, that they should be restricted to a minimum and limited, as far as possible, to those classes where no other mode of preservation is practicable. The constantly increasing facilities of travel, the comparative economy with which fresh specimens can be studied, the superiority of such work (with proper appliances) to that of the museum, the daily increasing number of workers who are able, on the seashore or in the field, to produce results unattainable by museum study alone, show that the time has come when large collections must naturally be supplemented by zoölogical stations. These, when once established at properly selected localities, will enable museums to dispense with much that is now exceedingly costly. They will become, for certain departments at least, chiefly depositories where the record of work done at the stations—the archives of natural science, so to speak—will be preserved, so that while their usefulness for the general instruction of the public and of our higher institutions will not be diminished, they must hereafter be useful to the original investigator in a somewhat more limited field.

CHAPTER VII.

MARINE LABORATORIES.

Only in comparatively recent times has the tremendous importance of the bearing of the invertebrates upon the general questions of biology been appreciated. We have seen that some work was done upon these animals at an early date, when the minds of workers were not much troubled by theoretical considerations, but the study of the adult forms is so small a part of a real understanding of these animals that it was unsatisfactory work, and never became popular among investigators until embryological methods had been introduced.

Dr. Brooks has remarked that "nearly every one of the great generalizations of morphology is based upon the study of marine animals, and most of the problems which are now awaiting a solution must be answered in the same way."* We find the reason for this in the fact that the biology of the present day is a study of vital phenomena and of natural laws governing living things. The importance of the invertebrates depends, therefore, upon the fact that in them life exists under simplified conditions, affording opportunities for the study of questions for which higher forms are, with our present knowledge, too complex.

As the study of invertebrates has extended, it has become more and more desirable to have more favorable conditions for this work, more abundant facilities for collecting and opportunities for studying animals alive. Much of the early work was done upon specimens collected and stored in museums, but workers, both in this country and Europe, had frequently made excursions to the seacoast for the purpose of studying the invertebrate forms constituting so large a part of the marine fauna.

The unsatisfactory nature of this work was of course evident. Suitable accommodations and working appliances could not be provided under these circumstances, and desirableness of establishing permanent seaside laboratories was early felt. Nothing was done, however, in this country until 1871, when John Anderson, a wealthy citizen of New York, presented to Professor Agassiz the island of Penikese in Buzzard's Bay, together with the sum of \$50,000 with which to found a seaside station for the study of marine life. Another friend gave him a yacht of 80 tons burden for use in collecting. Agassiz had long wished for such a laboratory, and no one but himself could have aroused the necessary enthusiasm for carrying out the project. He soon set to work and built large lab-

* Johns Hopkins University Circulars, vol. 6, p. 37.

oratories, with suitable accommodations for a large number of workers. In 1873 they were opened for work. This constituted the first opportunity enjoyed by American students of studying marine animals in their native waters, with proper appliances for work. It inaugurated a new era in scientific research, being the first outward expression of an idea which has since taken a firm hold upon the investigators of the country. The death of Agassiz in December, 1873, put an end to the project. The buildings were used but two seasons and then abandoned.

Of this laboratory Professor Whitman says:

At the close of the second and last season at Penikese, in 1874, Alexander Agassiz appealed to the colleges and all interested boards of education for support; but all in vain, for not a single favorable reply was received, and so his intention to remove the laboratory to Wood's Holl was never carried out. Thus that great and memorable undertaking, after absorbing money enough to build and equip a most magnificent laboratory, was abandoned from lack of interest on the part of educational institutions rather than of means. Such a failure, it must be frankly confessed, is not one to inspire confidence, but its explanation removes the apparent grounds for discouragement. It was the marvelous personality of Professor Agassiz that made Penikese a possibility. It was his magic influence that created that school, his commanding individuality that organized and vitalized it. All interests centered in him so completely that with his sudden removal the enterprise was left without a soul. The school had no coherency except in his magnetic power and intellectual strength, and the moment these elements of stability were withdrawn, collapse followed as a natural and inevitable consequence. Then, too, it should be remembered that Professor Agassiz lived just long enough to demonstrate the impracticability of maintaining such a school in such a locality, but unfortunately not long enough to convince the scientific world of its utility: The school was an experiment; its master was stricken down before it could be fairly tested, and the times were not ripe for it.

The establishment of this laboratory was an event of the greatest significance because of its bearings upon the history of education. Not only was Penikese the first biological station established in this country, and, indeed, in the world, but it was the beginning of the summer-school movement which has spread so generally over the country, and which, it should be noted, began with original research and finally extended to include the work of elementary instruction.

The movement met with the cordial support of naturalists everywhere, and was almost immediately followed by the establishment of Dohrn's magnificent station at Naples. Soon after, in 1875, a seaside station was established at Helder by the Netherlands Zoölogical Society, and other smaller ventures followed in Europe.

The need of opportunities for seaside study in this country was too generally felt by those who had come under Agassiz's influence for the project to be allowed to stop. The advantages of this method of work over museum study had impressed themselves at least upon a few workers, and accordingly we find several attempts made to found new laboratories. They differed in character and aims, but all agreed in being founded upon the one idea of studying marine animals in their native waters.

The most direct successor of the Penikese laboratory is the private laboratory of Prof. Alexander Agassiz at Newport. While this building is constructed on a much smaller scale than that at Penikese and is open only to a limited number of workers, yet it is prominent for the elegance of its appointments and its conveniences for work.

The first laboratory for seaside study established in this country after the abandonment of Penikese was maintained by the Peabody Academy of Sciences, under the guidance of Professor Packard, with the coöperation of Professor Kingsley and others. This laboratory was for elementary instruction rather than research, and remained in existence only from 1876 to 1881.

In 1878 the trustees of the Johns Hopkins University made an appropriation to allow a party of workers to spend some time in seaside study. The party was under the guidance of Dr. W. K. Brooks, who had himself been a pupil of Agassiz and a member of the Penikese laboratory. The location selected was at the lower part of the Chesapeake Bay, from which the name Chesapeake Zoölogical Laboratory was chosen. No permanent buildings were erected, as it was intended, if possible, to change the location from year to year; but an outfit of boats and collecting apparatus was provided. The summers of 1878 and 1879 were spent about the lower part of Chesapeake Bay at Crisfield, Md., and Fort Wool, Va., at which places special attention was given to the development of the oyster.

At the opening of the third season, in 1880, the need was felt of a locality that would offer a greater variety of objects for study, and accordingly the summers of 1880-82 were spent at Beaufort, N. C. This locality proved especially favorable, since sand bars, mud flats, salt marshes, and land-locked salt water, within easy reach, gave a large variety of different rare forms, and there was also abundant ocean dredging. A sufficient appropriation was made in 1880 to purchase a steam launch and a sloop, which put the workers in a position to take every advantage of their opportunities.

In 1883 a special study of oyster beds made a return to the mouth of the Chesapeake Bay necessary, and that season was spent at Hampton, Va., but the following two seasons were again spent at Beaufort.

In 1886 the need of a more southern location was felt, and the Bahama Islands seemed to offer an inviting field. The summer of 1886 was therefore spent at Green Turtle Cay, and the following summer at Nassau, New Providence.

Financial difficulties temporarily stopped the work of the laboratory, but it is announced that it will be reopened in the summer of 1891.*

It is difficult to summarize the work of this laboratory, and none the less so to overestimate its importance. It enjoys the distinction of

* Shortly after the above was written, Kingston, Jamaica, was chosen as a suitable locality, and a party of advanced workers, numbering about 14 in all, were present from May until September.—Sept. 21, 1891.

being the first marine laboratory ever carried successfully into operation in this country, and its work was entirely original research. The character of work done differed from year to year, according to the facilities which the different localities offered; but in general it may be said that embryology received most attention, while considerably less was devoted to the discovery and description of new species. The methods employed, as well as the new facilities enjoyed, made it possible to apply effective means of solution to many problems previously obscure, as well as opening many questions in regard to which nothing had been done.

Of the lasting value of the work it is perhaps too early to speak, but the fact that over one hundred papers, based upon work there performed, have readily found publication in the best journals of this country and Europe, as well as the fact that much of the work has already found its way into standard text-books, gives strong testimony to its value.

The Chesapeake Zoölogical Laboratory may be regarded as the successor of the Penikese laboratory to the extent that its aims are the same, but it differed in not being generally open to the workers of the country. Arrangements were not made for large numbers, and those who were present were mainly students of the Johns Hopkins University. During the 9 years that this laboratory remained in existence, there were in all fifty investigators present, and the average length of each session was nearly 2 months.

The need was felt, especially in that portion of the country where Agassiz's influence was more directly exerted, of establishing a laboratory on a larger scale and open to a larger number of workers, and the first step taken in this direction was the founding of a laboratory by the Boston Society of Natural History. In their report for 1881 these words occur:

It has been considered desirable to found a summer laboratory sufficient to supply the needs of a class of persons who have begun to work practically under our direction, but have hitherto had no convenient means for pursuing their studies on the seashore. * * * We are sure that such a laboratory is needed for a limited number of persons, such as our own pupils in natural history, and some of the teachers of the Boston public schools, about a dozen in all, but we are not sure of any real demand outside of these.

Arrangements for laboratory work were speedily made at Annisquam, Mass. Boats and appliances for collecting were at once provided, and in the spring of 1881 a circular was issued announcing the opening of the new laboratory. From this the following extracts are taken:

The liberality and coöperation of the Woman's Educational Association enable the Boston Society of Natural History to announce that a seaside laboratory, under the direction of the curator (Prof. Alpheus Hyatt), and capable of accommodating a limited number of students, will be open at Annisquam, Mass., from June 5 to September 15.

The purpose of this laboratory is to afford opportunities for the study and observation of the development, anatomy, and habits of common types of marine animals,

under suitable direction and advice. There will therefore be no attempt during the coming summer to give any stated course of instruction or lectures.

It is believed that such a laboratory will meet the wants of a number of students, teachers, and others who have already made a beginning in the study of natural history.

Twenty-two persons were attracted to the Annisquam laboratory during its first season. Professor Hyatt, in his report for 1882, remarks as follows:

The great need of an institution for teaching field work can not be properly estimated by the number of those who are attracted by the opening of such opportunities for study. The mental condition of those who attend, and what it has done for them, and the sphere of influence which it reaches through them, are the only true standards by which its present and future usefulness can be properly measured. Nearly all the pupils were persons who could be termed "well educated;" nevertheless they were, with the exception of some who had already worked in the laboratory or field, entirely unable to obtain knowledge with their own eyes and hands, and had even acquired a notion that this was not possible for anybody except the trained scientist. Several of these teachers, after their work was finished, expressed their gratefulness for the new powers the course had developed in themselves, and the fascinating pleasure they had experienced in learning to use their own eyes and hands in the study of things hitherto unapproachable for their uncultivated senses except through the deceptive mediation of books. When it is remembered that these teachers influence and mold the minds of thousands of young persons it is at the same time proved that what this laboratory has done and can do is not to be estimated by the number of its own pupils.

The success of the undertaking seemed assured, and arrangements were made for its continuance during the 5 years following. The number of students fluctuated greatly, falling to ten in the third year and running up in the sixth year to twenty-six.

During these 6 years the laboratory was carried on jointly by the Boston Society of Natural History and the Woman's Educational Association, of Boston. It has been the policy of both of these associations to originate new enterprises, but to turn them over when well started into other hands. It seemed in 1887 that the time had come when the maintenance of the laboratory should be put on a firmer basis. It had been supported long enough to demonstrate its practicability and usefulness. The demands upon it had increased. It was no longer an experiment. The associations believed that a permanent organization should be effected, the working facilities increased, and the whole established on a larger scale. Moreover, it seemed that something more might be done to give the laboratory a wider sphere of usefulness in advancing knowledge of marine life. Great as was its work in teaching, it seemed to depend for its support upon a circle of people too small for the extent of its benefits. It seemed desirable that a change should come which would lead to a more widespread interest in the laboratory, and bring together more investigators.

The Marine Biological Laboratory, which is elsewhere mentioned, was the result of this movement.

While space will permit but a brief account of this laboratory, its

history, development, aims, etc.; it may be said that the one point which distinguished it from the Annisquam laboratory was the prominence given to research. As is elsewhere stated, students are received, but from the outset there has been a settled determination to so adjust the claims of each as to secure the greatest amount of efficiency and do most to advance science. The organization was therefore effected so as to secure a permanent staff of investigators, who would always be present, increasing knowledge by their own work, and by their example stimulating others to follow. Moreover, the principle was thoroughly recognized that the best investigation is prompted by the work of teaching. The best investigator is often the best teacher, but the work of teaching reacts upon the work of investigation, influencing it for the better.

The experience of the laboratory shows that these points, which had previously been carefully considered, were well taken. Various means were resorted to for providing funds, and in March, 1888, the laboratory was incorporated.

Wood's Holl was chosen as a locality because of its convenience, accessibility, and the variety of its land and marine flora and fauna. The building was at once begun, and finished in time for work during the summer. Circulars could not be issued until after most of the colleges had disbanded for the summer, and yet during the first season seven investigators and eight students were attracted to the laboratory.

In subsequent years the growth has been a steady one. The number of workers has greatly increased, and even now, when only its third season has been passed, it is stated that the space is insufficient to meet the demands upon it; the facilities for collecting are too small, and the staff of instructors is not large enough for their classes. Its usefulness is now established, and the time is ripe for it. To it in great measure the country must look for the advancement of biology. Let us hope that its trustees, all of whom are working biologists, may be successful in placing the laboratory upon such a financial basis that its full possibilities for usefulness may be realized.

TABLE 1.—*Showing statistics bearing upon biological teaching in colleges.*

NOTE.—In order to give as accurate a basis of comparison as possible, the enumerations here given include only the faculties and students in the regular collegiate courses; all those connected with professional schools being excluded. In most cases the statistics have been compiled from catalogues for 1889-90. In the cases of institutions marked with an asterisk earlier catalogues were used.

Name of college.	Location.	Name and title of professor.	Number of associates or assistants.	Number of professors.	Number of students.
Adelbert College.....	Cleveland, Ohio.....	F. H. Herrick, Ph. D., instructor in biology.	None	16	72
Agricultural and Mechanical College of Texas.....	College Station, Tex.....	F. L. Brunk, B. S., associate professor of horticulture and botany.	do	20	207
Albion College.....	Albion, Mich.....	Delos Fall, A. M., professor of biology and chemistry.	do		
Allegheny College.....	Meadville, Pa.....	J. H. Montgomery, Ph. D., professor of physics and chemistry.	do	11	95
Amherst College.....	Amherst, Mass.....	John M. Tyler, Ph. D., Stone professor of biology.	do	15	175
Amity College.....	College Springs, Iowa.....	N. Y. Davis, professor of natural science.	do	30	344
Arkansas Industrial University.....	Fayetteville, Ark.....	F. W. Simonds, M. D., Ph. D., professor of biology and geology.	do	6	217
Augsburg College.....	Rock Island, Ill.....	J. A. Udden, professor of natural history and geology.	do	24	504
Beloit College.....	Beloit, Wis.....	R. D. Salisbury.....	do	14	66
Bowdoin College.....	Bowdoin, Me.....	L. A. Lee, professor of biology.		15	58
Brown University.....	Providence, R. I.....	A. S. Packard, M. D., Ph. D., professor of zoology and geology.	3	14	137
Bryn Mawr College.....	Bryn Mawr, Pa.....	E. R. Wilson, Ph. D., professor of biology.	2	20	285
Buchtel College.....	Akron, Ohio.....	E. W. Claypole, B. S., professor of natural science.	None	20	122
Carleton College.....	Northfield, Minn.....	L. W. Chaney, M. S., professor of biology and geology.	do	12	93
Central Wesleyan College.....	Warrenton, Mo.....	J. H. Frick, A. M., professor of mathematics and natural sciences.	do	16	74
Clark University.....	Worcester, Mass.....	C. O. Whitman, Ph. D., professor of geology.	do	7	47
Colby University.....	Waterville, Me.....	W. S. Bayley, Ph. D., professor of zoology.	None		
Colgate University.....	Hamilton, N. Y.....	A. H. Cole, A. M., lecturer on natural history.	do	10	119
College of New Jersey.....	Princeton, N. J.....	George Macleakie, LL. D., D. Sc., professor of biology.	3	15	136
Colorado Agricultural College.....	Fort Collins, Colo.....	William McEachran, M. D., professor of biology.	None	49	769
Columbia College.....	New York, N. Y.....	A. A. Julian, A. M., Ph. D., instructor in biology and microscopy.	2	12	66
Cornell University.....	Ithaca, N. Y.....	B. G. Wilder, B. S., M. D., professor of physiology, comparative anatomy, and zoology.	5	102	563
Dartmouth College.....	Hanover, N. H.....	C. H. Hitchcock, Ph. D., professor of geology and mineralogy, and instructor in biology.	1	98	1,083
Davidson College.....	Davidson, N. C.....	H. L. Smith, A. M., professor of natural philosophy.	None	20	242
Denison University.....	Granville, Ohio.....	C. L. Herrick, A. M., professor of geology and natural history.	do	8	102
De Pauw University.....	Greencastle, Ind.....	O. P. Jenkins, Ph. D., professor of chemistry.	do	9	75
Earham College.....	Richmond, Ind.....	D. W. Dennis, Ph. D., professor of chemistry and biology.	do	23	286
Franklin and Marshall College.....	Lancaster, Pa.....	D. S. Weaver, B. S., M. D., lecturer on biology.	do	15	147
Furman University.....	Greenville, S. C.....	W. F. Watson, A. M., professor of physics and chemistry.	do	10	144
Georgetown College.....	Georgetown, Ky.....	J. F. Eastwood, Ph. D., professor of natural science.	do	5	132
Hamline University.....	Hamline, Minn.....	H. L. Osborne, professor of biology and geology.	do	9	111
Hanover College.....	Hanover, Ind.....	G. L. Goodale, M. D., professor of natural history.	do	8	43
Harvard University.....	Cambridge, Mass.....	M. D., professor of cryptogamic botany; E. L. Mark, Ph. D., professor of anatomy.	7	9	89
Haverford College.....	Haverford College, Pa.....	W. S. Hall, M. S., M. D., instructor in biology.	None	102	1,274
Howard College.....	East Lake, Ala.....	G. W. Macon, professor of chemistry and biology.	do	14	91

Illinois College.....	Jacksonville, Ill.....	Vacant at time of report.....	do.....	11	54
Illinois Wesleyan University.....	Bloomington, Ill.....	M. J. Elrod, M. A., adjunct professor of chemistry, physics, and biology.....	do.....	8	88
Indiana University.....	Bloomington, Ind.....	C. H. Gilbert, Ph. D., professor of zoology; J. H. Campbell, Ph. D., professor of botany.....	None.....	24	319
Iowa College.....	Grinnell, Iowa.....	E. H. Barbour, Ph. D., professor of zoology and entomology.....	do.....	14	239
Iowa State College of Agriculture and Mechanic Arts.*	Ames, Iowa.....	H. Osborn, M. S., professor of zoology and entomology.....	do.....	38	267
Johns Hopkins University.....	Baltimore, Md.....	H. N. Martin, D. Sc., F. R. S., professor of biology; W. K. Brooks, Ph. D., professor of animal morphology.....	2	58	404
Kentucky University.....	Lexington, Ky.....	A. Fairbairn, professor of natural sciences.....	None.....	11	137
Lafayette College.....	Easton, Pa.....	T. E. Porter, D. D., LL. D., professor of botany, zoology, and geology.....	do.....	28	311
Lake Forest University.....	Lake Forest, Ill.....	W. A. Lucy, M. S., professor of biology.....	do.....	15	84
Lawrence University.....	Appleton, Wis.....	F. Cramer, E. L., professor of natural history and geology.....	do.....	8	75
Lenox College.....	Hopkinton, Iowa.....	A. G. Wilson, A. M., professor of natural and physical sciences.....	do.....	6	80
Lombard University.....	Galesburg, Ill.....	F. W. Rich, R. S., professor of natural science.....	do.....	11	57
Louisiana State University.....	Baton Rouge, La.....	A. T. Prescott, M. D., professor of natural history and assistant professor of mathematics.....	do.....	11	144
Maine State College.....	Orono, Me.....	F. L. Harvey, M. S., professor of natural history.....	1	12	131
Maryland Agricultural College.....	Agricultural College P. O., Md.....	A. C. Wightman, Ph. D., professor of natural history.....	None.....	9	41
Massachusetts Agricultural College.....	Amherst, Mass.....	S. T. Maynard, B. Sc., professor of botany and horticulture; C. H. Fernald, Ph. D., professor of zoology.....	do.....	14	132
Massachusetts Institute of Technology.....	Boston, Mass.....	W. T. Sedgwick, Ph. D., associate professor of biology.....	1	91	909
Miami University*.....	Oxford, Ohio.....	C. W. Hargitt, A. M., professor of biology and geology.....	None.....	8	45
Michigan Agricultural College.....	Lansing, Mich.....	A. J. Cook, M. S., professor of zoology and entomology; W. J. Beal, M. S., Ph. D., professor of botany.....	2	23	340
Mills College*.....	Mills College, Cal.....	J. Keep, professor of natural science.....	None.....	7	70
Milton College*.....	Milton, Wis.....	S. S. Maxwell, professor of natural science.....	None.....	11	138
Monmouth College.....	Monmouth, Ill.....	A. J. Bigney, A. B., professor of natural science.....	do.....	7	102
Moore Hill College.....	Moore Hill, Ind.....	C. M. Clapp, Ph. D., professor of zoology; H. E. Hoeker, Ph. D., professor of botany.....	1	39	272
Mount Holyoke College.....	South Hadley, Mass.....	J. A. Bauman, professor of natural science.....	None.....	12	76
Mount Union College*.....	Alliance, Ohio.....	O. Mary, LL. D., professor of natural history.....	None.....	5	41
Muhlenberg College*.....	Allentown, Pa.....	A. W. Wright, A. M., professor of geology and natural history.....	1	26	253
Northwestern University.....	Evanston, Ill.....	D. S. Keilbeck, Ph. D., professor of zoology and comparative anatomy.....	None.....	33	541
Oberlin College.....	Oberlin, Ohio.....	A. D. Merrill, A. M., M. S., professor of biology.....	2	34	425
Ohio State University.....	Columbus, Ohio.....	F. M. McFarland, Ph. B., professor of biology and geology.....	None.....	12	71
Ohio University.....	Athens, Ohio.....	L. H. McFadden, professor of natural science.....	do.....	12	125
Olivet College.....	Olivet, Mich.....	A. H. Conrad, M. S., professor of natural sciences.....	do.....	14	169
Ottobeen University*.....	Waterville, Ohio.....	H. T. Fernald, Ph. D., professor of zoology; W. A. Buckhous, M. S., professor of botany and horticulture.....	1	9	115
Parsons College.....	Fairfield, Iowa.....	B. F. Sharpe, adjunct professor of physics and biology.....	None.....	19	114
Pennsylvania State College.....	State College, Pa.....	P. F. Nelson, Ph. D., professor of biology.....	None.....	17	194
Randolph Macon College.....	Ashland, Va.....	C. O. Townsend, B. S., professor of natural philosophy, astronomy, chemistry, zoology, and botany, and lecturer on mineralogy and geology.....	1	23	187
Rutgers College.....	New Brunswick, N. J.....		None.....	11	98
St. Johns College.....	Annapolis, Md.....				

† This enumeration includes the school of art and school of mines.

TABLE 1.—*Showing statistics bearing upon biological teaching in colleges—Continued.*

Name of college.	Location.	Name and title of professor.	Number of associates or assistants.	Number of professors.	Number of students.
St. Johns University*	Collegeville, Minn.	A. E. Hervey, Ph. D., professor of natural science.	None	9	47
St. Lawrence University	Canton, N. Y.	J. H. Beal, Ph. B., professor of natural science and commercial law.	do	8	67
Selo College	Selo, Ohio	J. L. Tilton, A. M., professor of natural science.	do	7	220
Simpson College	Indianola, Iowa	T. H. Morgan, M. S., professor of natural science.	do	7	100
State College of Kentucky	Lexington, Ky.	S. Calvin, A. M., Ph. D., professor of geology and structural zoology.	do	15	384
State University of Iowa	Iowa City, Iowa	Spencer Trotter, M. D., professor of natural history.	3	26	296
Swarthmore College	Swarthmore, Pa.	L. M. Underwood, Ph. D., professor of geology, botany, and zoology.	None	24	163
Syracuse University	Syracuse, N. Y.	J. E. Todd, A. M., professor of natural sciences.	do	13	386
Tabor College	Tabor, Iowa	R. B. Riggs, Ph. D., professor of chemistry and natural science.	do	10	40
Tufts College	Hartford, Conn.	J. P. Marshall, A. M., professor of geology and mineralogy.	do	13	136
Tufts College	College Hill, Mass.	H. Orr, Ph. D., assistant professor of biology.	do	17	88
Tulane University	New Orleans, La.	J. H. Stoller, A. M., adjunct professor of natural history.	do	16	124
University of California	Berkeley, Cal.	C. Le Conte, M. D., LL. D., professor of geology and natural history.	1	44	362
University of Cincinnati	Cincinnati, Ohio	C. L. Herriot, M. S., professor of natural history.	None	14	121
University of Dakota	Vermillion, S. Dak.	C. L. Bristol, M. S., professor of biology.	do	15	61
University of Georgia	Athens, Ga.	J. P. Campbell, Ph. D., professor of biology.	do	13	160
University of Kansas	Lawrence, Kans.	F. H. Snow, professor of botany, entomology, and meteorology.	6	29	542
University of Michigan	Ann Arbor, Mich.	V. M. Steen, Ph. D., professor of zoology.	do	do	do
		V. M. Spalding, A. B., professor of botany.	4	59	1007
		H. H. Howell, Ph. D., professor of physiology.	1	25	564
University of Minnesota	Minneapolis, Minn.	H. F. Nachtrieb, M. S., professor of animal biology.	None	10	145
University of Mississippi*	University, Miss.				
University of Nebraska	Lincoln, Nebr.	C. E. Peasey, Ph. D., professor of botany.	2	27	250
		J. S. Kingsley, D. Sc., professor of agriculture and biology.	2	19	165
University of North Carolina	Chapel Hill, N. C.	J. A. Holmes, professor of geology and natural history.	10	52	314
University of Pennsylvania	Philadelphia, Pa.	J. Leidy, M. D., LL. D., professor of zoology and comparative anatomy.	1	16	180
University of Rochester	Rochester, N. Y.	H. L. Fairchild, B. S., professor of geology and natural history.	1	24	183
University of South Carolina	Columbia, S. C.	E. A. Smyth, A. B., adjunct professor of biology.	None	18	251
University of Tennessee	Knoxville, Tenn.	H. E. Summers, Ph. D., assistant professor of biology and zoology.	1	15	150
		F. L. Scribner, professor of botany and horticulture.	1	22	285
University of Vermont*	Burlington, Vt.	G. H. Perkins, professor of biology.	1	46	643
University of Virginia	Charlottesville, Va.	A. H. Tuttle, M. S., professor of biology and agriculture.	1	19	309
University of Wisconsin	Madison, Wis.	E. A. Birge, Ph. D., professor of zoology; C. E. Barnes, Ph. D., professor of botany.	None	23	112
		H. N. Mateer, M. D., Ph. D., professor of biology and geology.	2	12	166
University of Wooster	Wooster, Ohio	J. M. Sadoff, M. D., Ph. D., professor of natural history and geology.	1	11	218
Vanderbilt University	Nashville, Tenn.	J. M. Coulter, Ph. D., professor of biology and geology.	None	10	176
Wabash College	Crawfordsville, Ind.	W. L. Poteat, A. B., professor of natural history.	do	13	154
Wake Forest College	Wake Forest, N. C.	E. Linton, A. M., professor of biology.	do	23	220
Washington and Jefferson College	Washington, Pa.	H. D. Campbell, Ph. D., professor of geology and biology.	1		
Washington and Lee University	Lexington, Va.	H. W. Conn, Ph. D., professor of biology.	1		
Wesleyan University	Middletown, Conn.				

West Virginia University*	Morgantown, W. Va.	J. W. Hartigan, A. M., M. D., professor of biology.	None	13	68
Williams College	Williamstown, Mass.	S. F. Clarke, Ph. D., professor of natural history.	do.	22	313
Yale University	New Haven, Conn.	L. C. Eaton, M. A., professor of botany.			
		A. E. Verrill, M. A., professor of zoology.	3	101	1815
		S. I. Smith, M. A., professor of comparative anatomy.			
		R. H. Chittenden, Ph. D., professor of physiological chemistry.			

TABLE 2.—*Showing the biological work of arts courses,*

Institution.	Requirements for entrance.	Freshman—subject.	Length of course.	Hours for recitations.	Hours for laboratory.
Adelbert College	Chemistry, physics				
Albion College*	{ Physiology	{ Zoölogy	1 term ..	4 ..	
Allegheny College	{ Botany, physics	{ do	2 terms ..	5 ..	
	{ Physiology, physics	{ Botany	1 term ..	5 ..	
	{ Physical geography				
Amherst College		Anatomy and physiology	1 term ..	4 ..	
Amity College	{ Physiology, physics				
	{ Physical geography				
Brown University					
Buchtel College*		{ Zoölogy	1 term ..	3 ..	
Carleton College	Physics	{ Botany	1 term ..	4 ..	
Central Wesleyan College	{ Physiology, physical geography	{ Physiology	1 term ..	5 ..	
Colgate University					
Dartmouth College					
Denison University*	Physiology, physics	Chemistry	1 term ..		
Earlham College	Physiology, botany	do			
Franklin College*	{ Physics, physiology				
	{ Zoölogy, botany				
Franklin and Marshall College		{ Physical geography			
Georgetown College					
Hamline University					
Illinois Wesleyan University	{ Physics, physiology	{ Physiology	1 term ..	4 ..	
	{ Zoölogy, botany				
Iowa College*		Chemistry	1 year ..	3 ..	
Lafayette College					
Lawrence University	{ Physiology, physics	Zoölogy, (elective) ..	1 term ..	5 ..	
	{ Physical geography	Botany, (elective) ..	1 term ..	5 ..	
		{ Physiology	1 term ..	5 ..	
		{ Zoölogy	1 term ..	5 ..	
		{ Botany	1 term ..	5 ..	
Lombard University					
Moores Hill College	{ Physiology, physics	{ Botany	1 term ..	5 ..	
	{ Chemistry				
Mount Holyoke College*	Physiology, physics	Chemistry	1 term ..	4 ..	
Northwestern University	Physiology, physics				
Oberlin College	{ Physical geography	{ Physics	1 term ..	58 ..	
	{ Physiology, physics				
Ohio University					
Olivet College*		Botany	1 term ..	5 ..	
Parsons College	Physiology	Botany	1 term ..	2 ..	
Rutgers College		{ Biology	2 terms ..	2 ..	1
		{ Botany	1 term ..	5 ..	
Scio College	Physical geography, physiology				
Simpson College	Physiology, physics, chemistry				

* Lecture hours may be used for laboratory work.

together with the scientific subjects required for admission.

Sophomore-subject.	Length of course.	Hours for recitations.	Hours for laboratory.	Junior-subject.	Length of course.	Hours for recitations.	Hours for laboratory.	Senior-subject.	Length of course.	Hours for recitations.	Hours for laboratory.
Physics				Biology							
Microscopy ..	1 term		6	do	1 year		6	Research class	1 year	1	
Botany	1 term	4		Biology (elective).	1 term	4		Biology (elective).	2 terms		2
				Zoölogy	1 term	4		Zoölogy	1 term		4
Geology				Biology	1 term	5	6				
				Zoölogy	1 term	5	6				
Botany	1 year	3		Botany	1 term	5	6				
				Botany (elective).	1 year	3					
Vegetable physiology.	1 term	4		Zoölogy	1 year	3	3	Comparative anatomy.	1 term	4	
Botany	1 term	4	4	Biology	1 term	4					
do	1½ terms	5									
Zoölogy	1½ terms	5									
				Physiology ..	2 terms	3					
				Zoölogy	1 term	5					
				do	36 hours.						
Physiology ..	1 term	4		do	8 weeks.	5					
Botany	1 term	5									
Zoölogy	1 term	5		Botany (elective).	1 year		6				
Biology	2 terms	5		Zoölogy	1 year	3					
Botany	1 term	5		do	2 terms	2					
Biology	1 term	2		Histology	1 year		†	Embryology ..	1 year		†
Botany	2 terms	2						Physiology ..	1 year		5
Chemistry ..				Biology	2 terms			Botany	1 year		5
				Botany	1 term		†	Physiology ..	2 terms	5	
Zoölogy	1 term	4		Natural history.	1 year	3		Natural history (elective).	1 year	3	
Physics	1 year	3						Botany and zoölogy.	1 term	5	
				Physics and chemistry.				Biology	1 year		2
				General biology.		5					
Physiology ..	1 term	5		Structural botany, (elective).	1 term	5					
				Zoölogy (elective).	1 term	5					
Botany	1 term	4		Zoölogy	1 term	3		Biology (elective).	2 terms	3	
Zoölogy	2 terms	1		Botany	1 term	3	3	Biology (elective).	1 term	3	
Botany (elective).	1 term	5		Zoölogy (elective).	1 term	4					
Botany	1 term	1		Zoölogy	1 term	2					
Physiology ..	2 terms	3									
Botany	1 term	5		Physiology (elective).	1 term	5					
				Biology	1 term	4					
Botany	1 term	4		Zoölogy (elective).	2 terms						
				Biology (elective).	2 terms	5					
Zoölogy	1 term			Botany	1 term						
Botany	1 term	5		Zoölogy	1 term	2					

† 1 afternoon.

‡ 2 afternoons.

TABLE 2.—*Showing the biological work of arts courses,*

Institution.	Requirements for entrance.	Freshman—subject.	Length of course	Hours for recitations.	Hours for laboratory.
State College of Kentucky...	Physical geography.....	.....	.....	.....	.....
St. Lawrence University.....	.....	.....	.....	.....	.....
Swarthmore College*.....	Physiology, physics.....	Natural history	1 year.....	2.....	.....
Syracuse University.....		Physiology.....	1 term.....	3.....	.....
Tabor College.....	Physiology, physics.....	.....	.....	.....	.....
Union University.....	.....	.....	.....	.....	.....
University of Cincinnati.....	.....	Anatomy and physiology.....	1 year.....	2.....	.....
University of Georgia*.....	.....	.....	.....	.....	.....
Upper Iowa University.....	.....	.....	.....	.....	.....
Vanderbilt University*.....	.....	.....	.....	.....	.....
Washington and Jefferson College. }	.....	.....	.....	.....	.....
Williams College*.....	.....	.....	.....	.....	.....
Wesleyan University.....	.....	.....	.....	.....	.....

* Lecture hours may be used for laboratory work.

together with the scientific subjects required for admission—Continued.

Sophomore— subject.	Length of course.	Hours for recitations.	Hours for laboratory.	Junior—subject.	Length of course.	Hours for recitations.	Hours for laboratory.	Senior—subject.	Length of course.	Hours for recitations.	Hours for laboratory.
Botany and zoölogy.	$\frac{1}{2}$ year...	5	...	Physiology ...	$\frac{1}{2}$ year ...	5	...				
{ Physiology ...	$\frac{1}{2}$ year ...	4	...	}							
{ Botany ...	$\frac{1}{2}$ year ...	3	...	}							
Natural history	1 year ...	2	...								
Biology ...	1 term ...	2	2	Biology (elect- ive).	1 year ...	3	...	Zoölogy (elect- ive).	1 term ...	3	...
Botany ...	1 term ...	5	...	{ Zoölogy ...	1 term ...	5	...	}			
				{ Physiology ...	1 term ...	5	...	{			
				{ Physiology ...	1 term ...	5	...	{ Biology (elect- ive).	1 year ...	2	...
				{ Zoölogy ...	1 term ...	5	...	}			
{ Physiology ...	$\frac{1}{2}$ year ...	2	...	{ Biology ...	1 year ...	2	1	Biology ...	$\frac{1}{2}$ year ...	2	1
{ Botany ...	$\frac{1}{2}$ year ...	1	...	{ Biology and microscopy (elective).	1 term ...	5	...				
Botany ...	1 term ...	5	...	{ Physics ...	1 year ...	4	...				
				{ Chemistry ...	1 year ...	3	2	{ Zoölogy and botany.			
				{ Physiology ...	1 term ...	3	...	}			
				{ Zoölogy ...	1 term ...	3	...				
				{ Botany ...	1 term ...	2	...				
{ Biology and zoölogy.	$\frac{1}{2}$ year ...	3	...	{ Biology (elect- ive).	1 year ...	6	...	Biology (elect- ive).	1 year ...	6	...
{ Botany (elect- ive).	50 hours.			{ Biology (elect- ive).	85 hours.			{ Biology (elect- ive).	80 hours.		
				{ Zoölogy (elect- ive).	85 hours.			}			

TABLE 3.—*Showing the biological work of scientific courses,*

Institution.	Requirements for entrance.	Freshman—subject.	Length of course.	Hours for recitations.	Hours for laboratory.
Allegheny College.....	{ Physiology, physics	Zoölogy	2 terms ..	5 ..	
Amherst College*.....	{ Physical geography	Botany	1 term ..		
		Anatomy and phys- iology.	1 term ..	4 ..	
Amity College.....	{ Physiology, physics				
	{ Physical geography				
Arkansas Industrial Uni- versity.		{ Zoölogy	1 term ..	5 ..	
		{ Botany	1 term ..	5 ..	
Buchtel College.....	Same as in A. B. course.	{ Physiology.....	1 term ..	5 ..	
Carleton College*.....	Physiology, physics	{ Biology	125 hours.		
		{ Botany	50 hours.		
Colgate University	Physics, chemistry				
College of New Jersey		{ Botany	40 hours.		
		{ Anatomy and phys- iology.	16 hours.		
Dartmouth College	Physical geography	Botany	2 terms ..		
Denison University*.....	{ Physiology, botany				
	{ Physics, comp. anatomy.....				
Earlham College.....	Physiology, botany	Biology	1 term ..		10
Franklin College	{ Physiology, physics				
	{ Zoölogy, botany.....				
Georgetown College.....					
Hamline University		Zoölogy	1 year ..		6
Haverford College.....	Physiology, physics	Botany and hygiene.	1 year ..	2 ..	
Illinois College *.....	{ Physical geography, botany	Botany	1 year ..	5 ..	
	{ Zoölogy, physiology, physics.....	Anatomy and phys- iology.	1 term ..	5 ..	
Iowa College *.....	Physiology, physical geography.				
Lafayette College.....		Mineralogy			
Lake Forest University * ..	{ Physiology, physics	Biology	2 terms ..	4 ..	
	{ Botany, physical geography	Botany	1 term ..	3 ..	
Lombard University.....	Physical geography	Chemistry			
Lenox College	Botany, physiology.....	Botany	1 term ..		
Moorea Hill College	Physiology, physics, chemistry.	Botany	1 term ..		
Mount Holyoke College *.....	Physiology, physics.....	Chemistry			
Northwestern University..	{ Physics, physiology				
	{ Botany, astronomy				
Ohio State University.....	Botany, physics	Botany	1 year ..	2 ..	
Olivet College *.....	{ Physical geography	Botany	1 term ..	5 ..	
	{ Physiology, physics				
Parsons College	{ Physiology, physics	Botany	1 term ..	3 ..	
	{ Botany, zoölogy				
St. Lawrence University.....	Same as in A. B. course.	{ Physiology.....	1 term ..	5 ..	
Scio College *.....		{ Zoölogy	1 term ..	5 ..	

* Lecture hours may be used for laboratory work.

TABLE 3.—*Showing the biological work of scientific courses,*

Institution.	Requirements for entrance.	Freshman—subject.	Length of course.	Hours for laboratory.	
				Hours for recitations.	Hours for laboratory.
Simpson College*.....	{ Physical geography, physics... }	Chemistry.....	1 year...	4	...
	{ Physiology, chemistry..... }				
State College of Kentucky.....	{ Physical geography, botany... }	Physiology.....	$\frac{1}{2}$ year...	5	...
	{ Zoology, chemistry..... }	Botany and histology.	$\frac{1}{2}$ year...	5	...
Swarthmore College.....	Same as in A. B. course.				
Syracuse University.....	Same as in A. B. course.				
Tabor College.....	Physiology, physics.....	Botany.....	1 term...	5	...
Trinity College.....					
Tulane University.....	Physics, chemistry.....	Biology.....	1 year...	1	2
Union University*.....		Biology.....	1 term...	3	...
University of Georgia*.....					
Upper Iowa University*.....					
Vanderbilt University.....		Chemistry.....	1 year...	3	3
Washington and Jefferson College.....		Botany.....	2 terms...	3	...
Wealeyan University.....		Botany.....	50 hours.		

* Lecture hours may be used for laboratory work.

together with the scientific subjects required for admission—Continued.

Sophomore— subject.	Length of course.	Hours for recitations.	Hours for laboratory.	Junior—subject.	Length of course.	Hours for recitations.	Hours for laboratory.	Senior—subject.	Length of course.	Hours for recitations.	Hours for laboratory.
Botany.....	1 term ..	5		{ Zoölogy	1 term ..	2		{			
				{ Biology	1 term ..	5					
				Zoölogy	½ year ..	5		Microscopy	½ year ..		
{ Cryptogamic botany (elective).	{ 1 term ..			{ Zoölogy	1 term ..			{			
Biology	½ year ..	1		{ Physiology	1 term ..						
				{ Zoölogy (elect- ive).	1 term ..						
Biology	1 year ..	1	4	Zoölogy and botany.	1 year ..	2					
								Biology	1 year ..	6	
Botany	1 term ..	4		{ Physiology	1 term ..	4					
				{ Zoölogy	1 term ..	5					
				Botany (elect- ive).	1 term ..	2					
				Biology (elect- ive).	1 term ..	2					
{ Physiology	{ ½ year ..	2		Biology	1 year ..	2	1	Biology	1 year ..	2	1
{ Botany	{ ½ year ..	2		{ Biology and	1 term ..	5					
{ Zoölogy	{ 1 term ..	3		microscopy.							
{ Botany	{ 1 term ..	3		Botany and	½ year ..	2					
{ Botany and	{ ½ year ..	4		zoölogy.							
zoölogy.											
Biology	1 term ..	3									
Comp. anat- omy.	1 term ..	3		{ Physiology	1 term ..	2					
Cryptogamic botany.	1 term ..	3									
Physiology	65 hours.			{ Biology							
Zoölogy (elect- ive).	85 hours.				85 hours.			Biology	85 hours.		

INDEX.

A.

Adelbert College, 12.
 Agassiz, A. Marine Laboratory, 164.
 Agassiz, L. Influence on biological teaching, 126;
 on research, 148, 162.
 Agricultural colleges, influence of, 7; organiza-
 tion, 150.
 Agricultural experiment stations, 150.
 Agricultural and Mechanical College of Texas, 13.
 Agriculture, Department of, 150.
 Albion College, 13.
 Allegheny College, 14.
 American Academy of Arts and Sciences, 145.
 American Association for the Advancement of Sci-
 ence, organization, 148; Report on science teach-
 ing, 119.
 American Naturalists, 153.
 American Philosophical Society, 145.
 American Physiological Society, 151.
 American Society of Geologists and Naturalists,
 147.
 American Society of Naturalists, organization,
 151; Report on science teaching, 120.
 Amherst College, 15.
 Amity College, 16.
 Annisquam Laboratory, 166.
 Arkansas Industrial University, 16.
 Audubon, 144.
 Augustana College, 17.

B.

Baird, Spencer F., 149.
 Barton, Benjamin Smith, 125.
 Bartram, John, 143.
 Bartram, William, 144.
 Beloit College, 18.
 Bethel College, 18.
 Biological Instruction, history of, 125.
 Biological Investigation, history of, 143.
 Biology, work in schools, 115; work in colleges,
 123; work in universities, 140; inductive meth-
 ods in, 114-116; place in a general education, 137.
 Boston Society of Natural History, 146, 165.
 Botanical Gazette, 153.
 Bowdoin College, 19.
 Brooklyn Institute, laboratory of biological re-
 search, 19.
 Brooks, W. K., on marine laboratories, 162.
 Brown University, 20.
 Bryce, J., on American universities, 148.
 Bryn Mawr College, 21.
 Buchtel College, 22.

C.

California, University of, 82.
 Carleton College, 23.
 Catesby, Mark, 143.
 Central Wesleyan College, 24.
 Chesapeake Zoölogical Laboratory, 164.
 Cincinnati, University of, 83.
 Clark University, 24.
 Colby University, 26.
 Colden, Cadwallader, 144.
 Colgate University, 27.
 College of the Holy Cross, 27.
 College of New Jersey, 27.
 Colorado Agricultural College, 29.
 Colorado, University of, 84.
 Colton's Practical Zoölogy, 156.
 Columbia College, 30.
 Cornell University, 31.
 Cutler, Manassah, 144.

D.

Dakota, University of, 85.
 Dartmouth College, 34.
 Davidson College, 34.
 Denison University, 35.
 DePauw University, 35.

E.

Earlham College, 36.
 Elliott, Stephen, 144.
 Emerson, G. B., on Agassiz, 127.
 Emory College, 113.
 Experiment stations, Agricultural, 150.

F.

Farlow, appointment, 131; on order of teaching,
 129; on assistants, 134; investigation, 162.
 Fish Commission, U. S., 150.
 Forbes, on museums, 160.
 Franklin College, 37.
 Franklin and Marshall College, 38.
 Furman University, 38.

G.

Georgia, University of, 86.
 Georgetown College, Ky., 38.
 Georgetown College, D. C., 113.
 Gilman, D. C., on physiological investigation, 155.
 Glover, Townsend, 150.
 Gonzaga College, 113.
 Goode, G. Brown, 143-149.

Government, aid of, to biological work, 147.
 Gray, Asa, work as a teacher, 128; as an investigator, 148.
 Green, Jacob, 125.

H.

Hall, G. S., on university work, 142.
 Hamline University, 30.
 Hampden Sidney College, 3.
 Hanover College, 4.
 Harlan, Richard, 144.
 Harvard University, 40; early curriculum, 125.
 Haverford College, 42.
 Holy Cross, College of, 27.
 Hosack, David, 126.
 Howard College, 43.
 Hunter, William, 126.
 Hurley, T. H., order of teaching, 128; lectures, 137; educational value of biology, 139.

I.

Illinois College, 43.
 Illinois Wesleyan University, 44.
 Indiana University, 45.
 Iowa College, 47.
 Iowa State College of Agriculture and Mechanic Arts, 47.
 Iowa, State University of, 76.

J.

Johns Hopkins University, 49.
 Journal of Morphology, 153.

K.

Kansas, University of, 87.
 Kentucky, State College of, 75.
 Kentucky University, 52.
 Kuhn, Adam, 126.

L.

Laboratory equipment, 156.
 Lafayette College, 52.
 Lake Forest University, 53.
 Lawrence University, 54.
 Lenox College, 54.
 Leoy, W. A., on laboratory work, 123, 156.
 Lombard University, 54.
 Louisiana State University, 55.

M.

Maine State College, 56.
 Marine Biological Laboratory, 57.
 Martin, H. Newell, appointment, 128; on investigation, 154.
 Maryland Agricultural College, 58.
 Massachusetts Agricultural College, 58.
 Massachusetts Institute of Technology, 59.
 Mercer University, 113.
 Miami University, 60.
 Michigan Agricultural College, 61.
 Michigan, University of, 88.
 Mills College, 82.
 Milton College, 62.
 Minnesota, University of, 90.
 Mississippi, University of, 91.
 Mitchell, John, 144.

Mitchill, Samuel Latham, 125.
 Monmouth College, 63.
 Moore's Hill College, 63.
 Mount Holyoke College, 64.
 Mount St. Mary's College, 113.
 Mount Union College, 65.
 Muhlenberg College, 65.
 Museum, National, 149.
 Museums, character of, 150.

N.

National Academy of Sciences, 151.
 National Institution for the Promotion of Science, 147.
 National Museum, 149.
 National University, 146.
 Nebraska, University of, 92.
 New England Society for the Promotion of Natural History, 146.
 New Jersey, College of, 27.
 Newman, J. H., on universities, 141.
 North Carolina, University of, 94.
 Northwestern University, 95.
 Nuttall, Thomas, 144.

O.

Oberlin College, 66.
 Observational powers, training of, 8, 117.
 Ohio State University, 67.
 Ohio University, 68.
 Olivet College, 69.
 Otterbein University, 69.

P.

Packard, A. S., letter on Agassiz, 126.
 Parsons College, 70.
 Peck, William Dandridge, 125, 144.
 Pennsylvania State College, 70.
 Pennsylvania, University of, 95.
 Philadelphia Academy of Natural Sciences, 145.

R.

Randolph-Macon College, 72.
 Rice, W. N., on science teaching in schools, 117.
 Richmond College, 113.
 Rochester, University of, 98.
 Rutgers College, 72.

S.

St. Benedict's College, 113.
 St. Charles College, 113.
 St. Ignatius College, 113.
 St. Johns College, 73.
 St. Johns University, 74.
 St. Lawrence University, 74.
 St. Louis University, 74.
 St. Xavier College, 113.
 Santa Clara College, 113.
 Say, Thomas, 144.
 Scio College, 74.
 Simpson College, 75.
 Smithsonian Institution, 149.
 South Carolina, University of, 90.
 Spalding, V. M., on museums, 150.
 Spring Hill College, 113.

State College of Kentucky, 75.
 State University of Iowa, 76.
 Swarthmore College, 78.
 Syracuse University, 79.

T.

Tabor College, 79.
 Tennessee, University of, 100.
 Tennessee State Teachers' Association, Report on
 science teaching, 122.
 Texas, Agricultural and Mechanical College of, 13.
 Text-books, use of, 136.
 Torrey, John, 144.
 Trinity College, 80.
 Tufts College, 81.
 Tulane University, 81.

U.

Union College, 82.
 University of Alabama, 113.
 University of California, 82.
 University of Cincinnati, 83.
 University of Colorado, 84.
 University of Dakota, 85.
 University of Georgia, 86.
 University of Kansas, 87.
 University of Michigan, 88.
 University of Minnesota, 90.
 University of Mississippi, 91.
 University of Nebraska, 92.
 University of North Carolina, 94.
 University of New Mexico, 113.

University of Pennsylvania, 95.
 University of Rochester, 98.
 University of South Carolina, 99.
 University of Tennessee, 100.
 University of Vermont, 101.
 University of Virginia, 102.
 University of Wisconsin, 103.
 University of Wooster, 105.

V.

Vanderbilt University, 106.
 Vermont, University of, 101.
 Virginia, University of, 102.

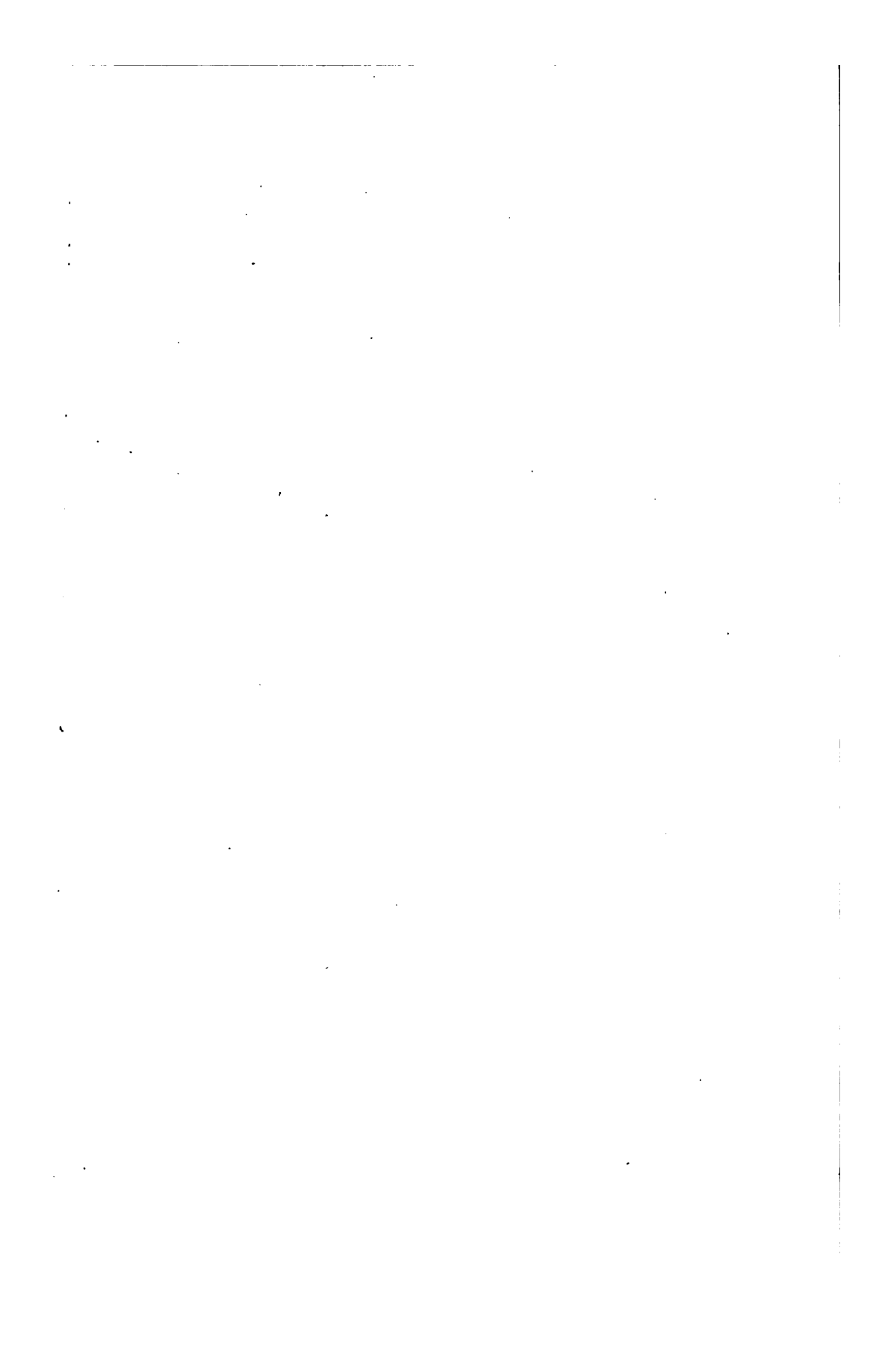
W.

Wabash College, 106.
 Wake Forest College, 107.
 Washington and Jefferson College, 108.
 Washington and Lee University, 108.
 Wesleyan University, 108.
 West Virginia University, 110.
 White, A. D., on university work, 140.
 Whitman, C. O., on organized investigation, 152.
 Wilder, B. G., on museums, 160.
 Williams College, 110.
 Wilson, Alexander, 144.
 Wisconsin, University of, 103.
 Wooster, University of, 105.

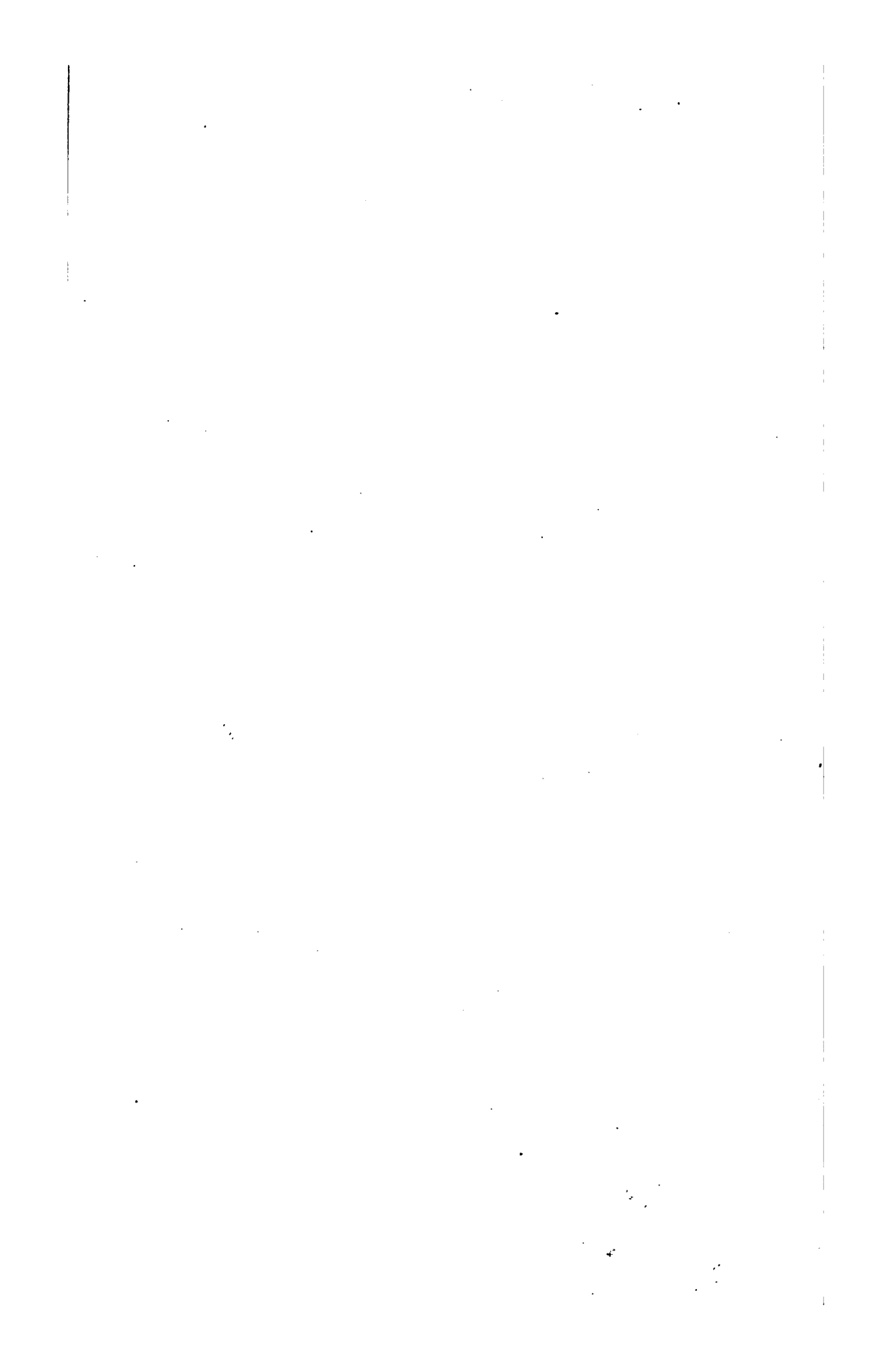
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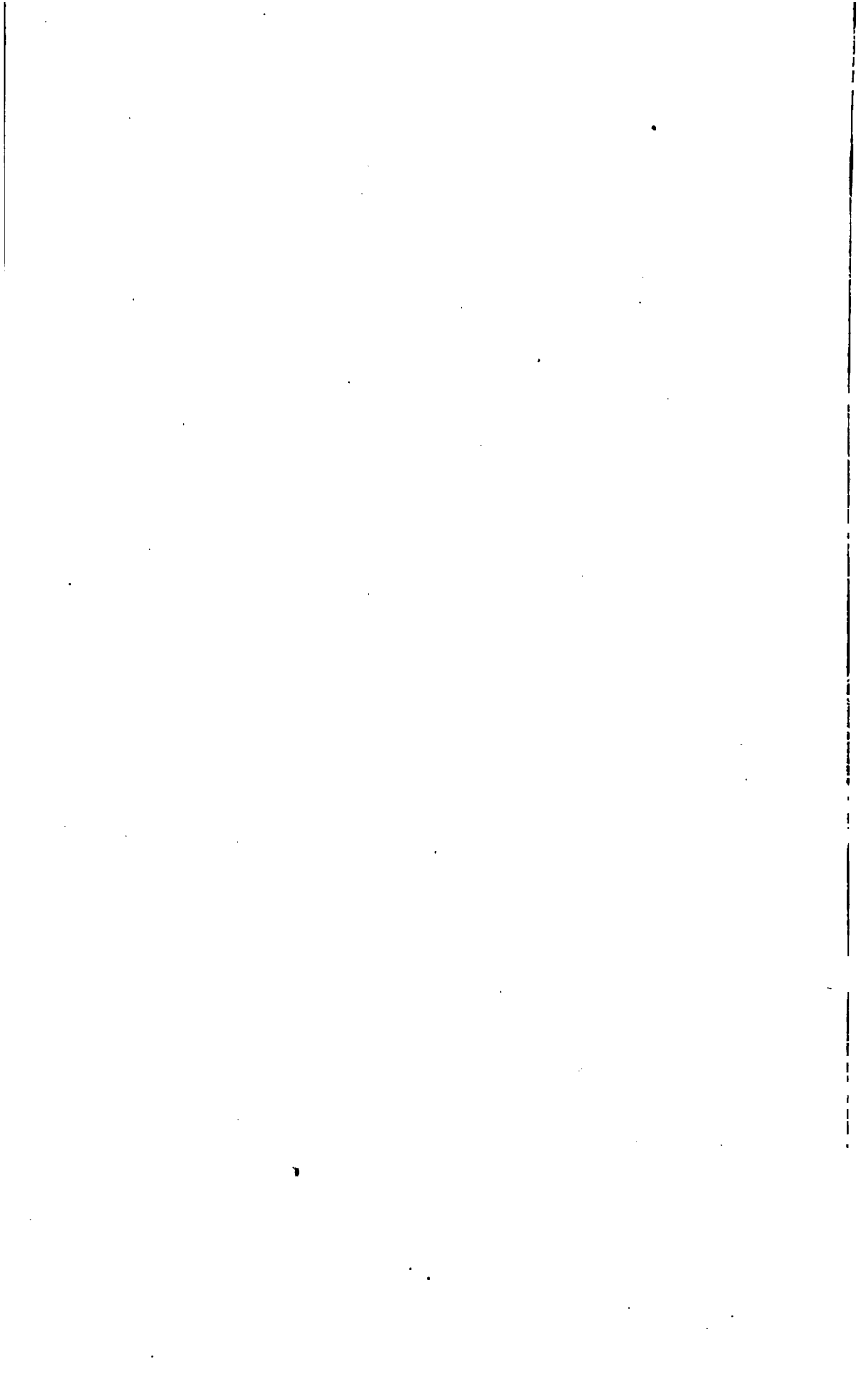
Yale University, 111.

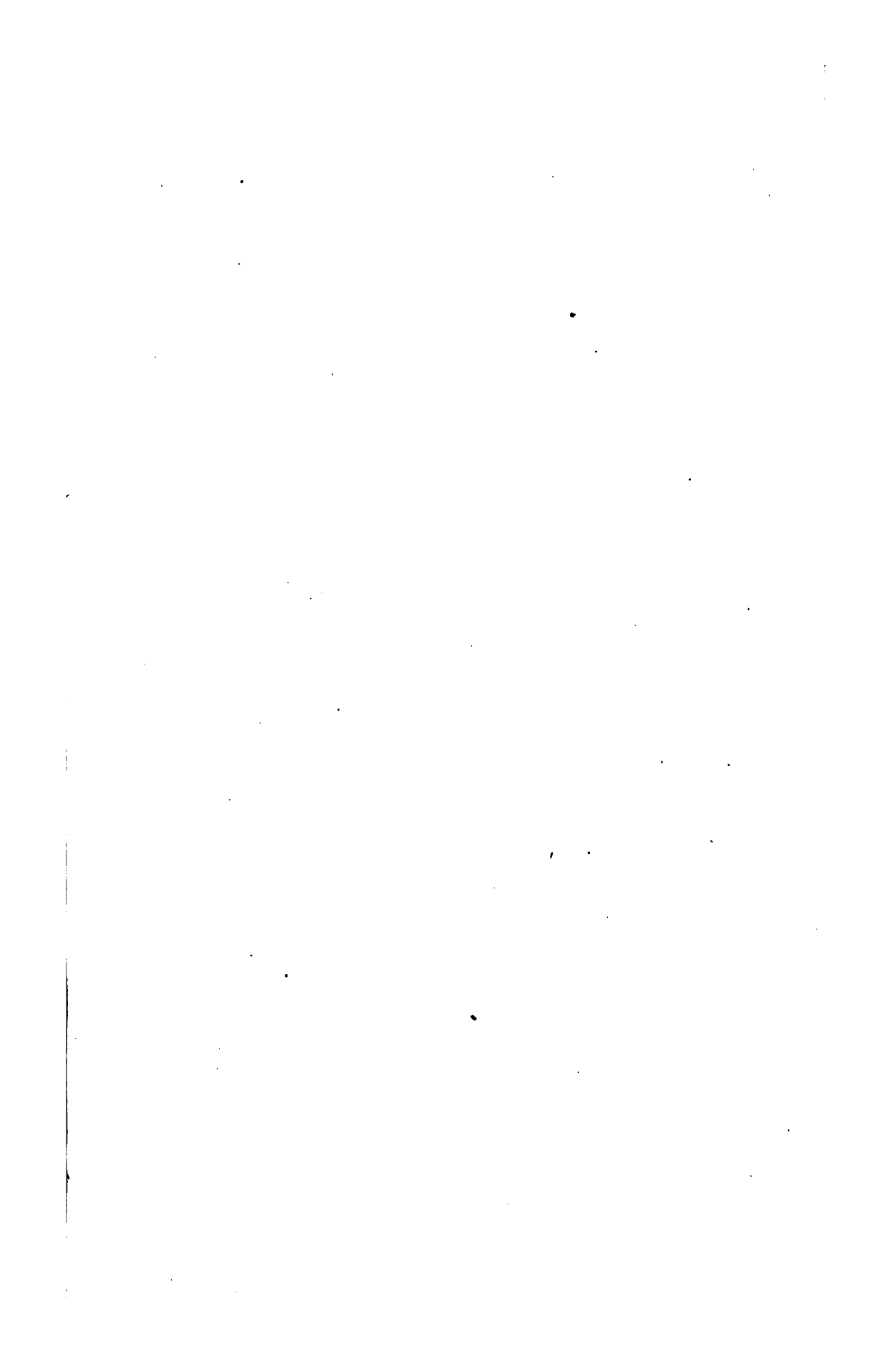


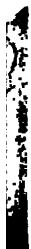














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